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VOL. 37 No. 329 MAY 1951

THE ROLE OF PEROXIDES IN THE CORROSION OF LEAD BY LUBRICATING OILS

By B. S. WILSON and F. H. GARNER (Fellow)

SUMMARY

The corrosion of lead by lubricating oils undergoing oxidation at about 150° C has been studied. Methods have been devised for the estimation of acidity, the peroxide content of the oils, and the rate of corrosion of lead.

On white oils the experiments showed a similarity between the shapes of the curves obtained for peroxide content and rate of corrosion, but a dissimilarity between these and the curve for acidity. During the early stages of the oxidation of white oils a yellow compound was observed on the surface of the lead which has been shown to be a basic lead salt of two or more organic acids. It has been shown that the peroxides generated in white oils are capable of effecting corrosion in the absence of air, provided that acids are present. Whilst the presence of oxygen is necessary for maximum corrosion, peroxides still have a controlling influence upon the rate of corrosion.

For engine oils the curves for peroxide content and rate of corrosion showed some similarity during continuous-oxidation experiments, but there was no similarity between either of these sets of curves and the curves for acidity. After a period of oxidation in the absence of lead, the engine oils were highly corrosive to lead, but this heavy rate of attack decreased quickly if they remained in contact with the metals. For these oils peroxides generated were only capable of producing very slight corrosion in the absence of air.

A theory has been put forward to explain the effect of atmospheric oxygen on the rate of corrosion by engine oils which had been previously oxidized for several hours in the absence of lead.

INTRODUCTION

THE mechanism whereby soft bearing metals are corroded by lubricating oils undergoing oxidation in an engine is not thoroughly understood. It is known that the oxidation resulting from agitation with air at high temperatures produces acidity in the oil, but earlier workers have shown that acidity alone is not responsible for the corrosion of bearing metals, and that the presence of an oxidizing agent is necessary before corrosion can take place.

White oils can develop high peroxide concentrations and high oxidation rates because of the lack of natural inhibitors. The addition of various percentages of a lubricating oil rich in natural anti-oxidants produces rapid decomposition of the white-oil peroxides.

Denison [1] made a series of corrosion tests in which a strip of bearing metal was suspended in white oil maintained at 200° F and oxygen fed in through a fritted glass plate; the loss in weight of the strips, the acidity, and the peroxide number of the oil were plotted as a function of time. The curves for corrosion rate and peroxide number were parallel and independent of the curve for acidity.

In a similar test a pure lead strip was used and periodically removed for observation. Denison states that once appreciable peroxides had formed in the oil, but prior to the development of appreciable acidity, the strip was heavily covered with salmon-coloured lead oxide; then, as appreciable acidity developed, the oxide coat dissolved off and corrosion proceeded.

Denison concluded that at least in highly refined oils, corrosion occurs as a result of the following reactions:

$$M + AO_2 = AO + MO$$
$$MO + 2HA = MA_2 + H_2O$$

where M = metal; AO_2 = peroxide; HA = organic acid.

Prutton and Day [2] determined the corrosive effects on pure lead of non-polar solutions of a typical high-molecular-weight organic acid (lauric) and *p*-quinone in the absence of oxygen. Lead was found to be rapidly corroded by oxygen-free xylene solutions of *p*-quinone and lauric acid, neither of which by itself attacks lead appreciably. In excess lauric acid the reaction was first order with respect to the quinone.

Prutton, Frey, Turnbull, and Dlouky [3] investigated the corrosion of metals by organic acids in hydrocarbon solvents and concluded that the presence of oxygen or peroxides is a necessary condition for the corrosion of lead and cadmium by fatty acids in hydrocarbon solvents.

Larsen,[4] in a recent review of the subject of bearing corrosion and engine-oil stability testing, lists many of the tests available and reviews the essentials required in these tests for simulating engine conditions. It is not difficult to choose an apparatus for studying the primary oxidation process, but in the study of bearing corrosion it is necessary not only to control the variables affecting oxidation but also to simulate the engine conditions prevailing at the bearing surface which lead to shear in the oil layer and the deposition or removal of protective coatings.

In the present work, only one metal, lead, has been used for the purpose of evaluating corrosion. The possible effects of numerous catalysts such as metallic iron, iron salts, and crankcase insolubles had to be ignored, and only one catalyst, copper, has been used. An average temperature of 150° C was chosen for the investigations on engine oils.

Whilst the process of oxidation of lubricating oils is not fully understood, it is known that acids are produced, and, in some oils, compounds of a peroxide nature are formed, possibly as intermediate compounds which exist for only a short time. This work is concerned with the investigation of such peroxidic compounds, their formation in relation to the degree of oxidation, and their effect on the rate of corrosion of lead. Whilst the exact nature of these compounds possessing oxidizing properties is not known, for the purposes of this report they are referred to as "peroxides."

The mixing of the oil with air was achieved by stirring the sample whilst exposed to the laboratory atmosphere. This agitation with atmospheric oxygen brings about the oxidation of the oil, with the result that compounds may be formed within the oil which are themselves oxidizing agents; the atmospheric oxygen present in the oil may not be the only oxidizing agent available for the support of corrosion, indeed it may be that it is only through chemical combination with the oil that this oxygen becomes available for assisting the mechanism of corrosion.

Apparatus

The apparatus, which is illustrated in Figs. 1 and 2, is a slight modification of that described in the Second Interim Report of the Oxidation Panel

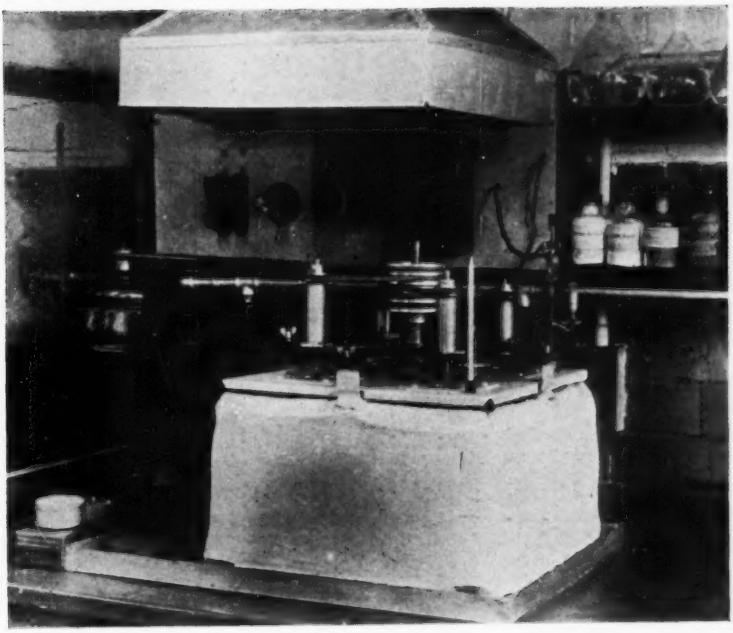

FIG. 1

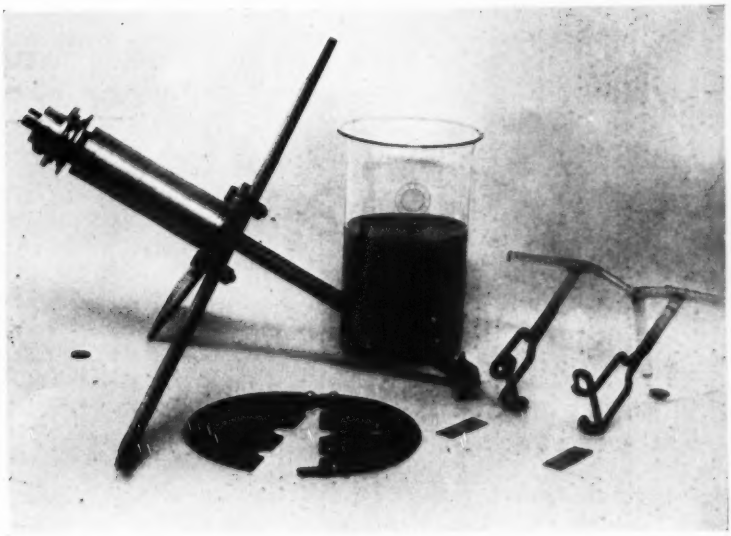

FIG. 2

To face p. 226.

of Standardization Sub-Committee 6 and is based on the Modified Indiana Stirring Corrosion Test.[5] It consists of a constant-temperature bath containing engine oil, which is heated by an electric immersion heater. The sides and base of the bath are covered with asbestos to reduce heat losses, and the temperature is controlled to within $\pm 0{\cdot}5°$ C by a mercury regulator which operates a Sunvic control. The heating oil is stirred by a brass paddle mounted on a central shaft revolving at about 400 r.p.m. The bath is fitted with a sheet-metal lid containing four holes, each 2·9 inches in diameter, so that four 400-ml tall-form beakers can be suspended in the bath with their lipless rims resting on the lid.

The oil under test is contained in these beakers and is stirred by a demountable stainless-steel paddle, the dimensions of which are shown in Fig. 3. Four samples or less can be tested at one time.

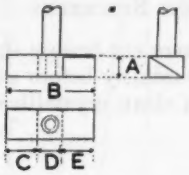

FIG. 3

STIRRER

A	0·8 cm
B	3·8 cm
C	1·5 cm
D	0·8 cm
E	1·5 cm

The specimens of lead and copper are supported in the oil under test by glass stirrups, one of which is illustrated in Fig. 2. They are designed so that the lead and copper strips are supported at diametrically opposite sides of the beaker, 1 cm from the side and 9 cm below the rim of the beaker.

THE DETERMINATION OF ACIDITY

It is necessary to choose a suitable solvent for the determination of acid contents of the oils and also an indicator whose colour change can be discerned in the presence of the deep brown colour produced in the solvent by the oxidized oils. The following method was adopted.

50 ml of alcohol (ethyl or *iso*-propyl) were placed in a 250-ml conical flask with 1 ml of phenol phthalein solution (0·5 per cent in ethyl alcohol), and standard potassium hydroxide solution added until the solution was just alkaline. 5 ml of the oil to be tested, at the temperature of the oxidation in progress, were then pipetted into the solution. The acids were dissolved in the alcohol by heating the flask on a water-bath for 5 minutes, stirring by swirling the flask. On removal from the water-bath the mixture was immediately titrated with 0·08*N*-potassium hydroxide solution until the red colour of the phenol phthalein was discernible and remained so after stirring.

THE DETERMINATION OF PEROXIDES

Two methods for the determination of peroxides were found to be suitable for the purposes of these experiments. The first, which was used during the experiments on white oils was a modified iodimetric method described by Wagner, Smith, and Peters.[6] The second was a modification of

Wheeler's method,[7] and was used for the experiments on the engine oils. In this method, 50 ml of a mixture of 50 per cent chloroform and 50 per cent glacial acetic acid were placed in a 250-ml conical flask and a 5-ml sample of the oil added. 4 g of sodium iodide were weighed into the flask, which was then attached to a condenser, heated over a small flame to reflux, and maintained at gentle reflux for 2 minutes. The flame was then extinguished, and as soon as reflux ceased, 50 ml of distilled water were poured down through the condenser into the flask. It was then disconnected and shaken vigorously, and 0·05*N*-sodium thiosulphate solution was run in until the end point was approached. A few drops of starch solution were then added, the flask shaken, and the titration continued to the end point, when the blue colour of the aqueous layer disappeared.

Preparation of Lead Test Specimens

Specimens of lead measuring 3 × 1 cm were cut from a sheet averaging 1 mm in thickness. They were cleaned chemically before use by treating them with Russel's solution [8] to produce a clean crystalline surface, and were stored in dry I.P. spirit.

Experimental Procedure

250 ml, at room temperature, of the oil to be tested were placed in a beaker which was lowered into the heating bath. After 15 minutes, the stirrup supporting the weighed test piece and copper catalyst was introduced, the stainless-steel stirrer bolted in position and the belt drive fitted. The oil was then stirred at 1100 ± 40 r.p.m. After the desired period of stirring the motor was stopped, the belt removed, and the stirrer unbolted and lifted out of the beaker. A second stirrup bearing a clean test piece and a catalyst was then inserted in the beaker, the stirrer and belt replaced, and stirring resumed.

The test piece, after removal from the oil, was immediately cleaned by brushing in benzene, dried, and reweighed. A 5-minute interval was allowed for the changing of the test pieces and during this time 5-ml samples of the oil were extracted by pipettes and placed in 250-ml conical flasks for the estimation of acidity and peroxides.

In a few experiments, an atmosphere of nitrogen was maintained above the surface of the oil in the beaker. A metal lid, illustrated in Fig. 2, was placed over the top of the beaker and a stream of nitrogen passed in by means of a glass tube inserted through a hole in the lid.

Experiments on White Oils

Oil	Sp. Gr. at 60° F	Viscosity (Sec Red 1 at 70° F)
A	0·859	95
B	0·884	105
C	0·874	102

Oil C is a blend of oils A and B.

At a temperature of 140° C, a sample of oil C was stirred in a beaker containing only the copper catalyst. Samples were taken for the estimation of peroxide content at half-hour intervals for the first 6 hours, then at hourly intervals for the following 19 hours. The results are plotted in Fig. 4, in which the peroxide content is expressed in ml oxygen per 100 ml oil, and shows an induction period of about 1½ hours, then a rapid rise to a maximum after 5 hours. This is followed by a gradual decrease to the end of the experiment.

A second sample of oil C was stirred in a beaker containing both catalyst and test piece. Every half-hour the test piece was changed and samples of oil extracted for the estimation of peroxide content and acidity. The

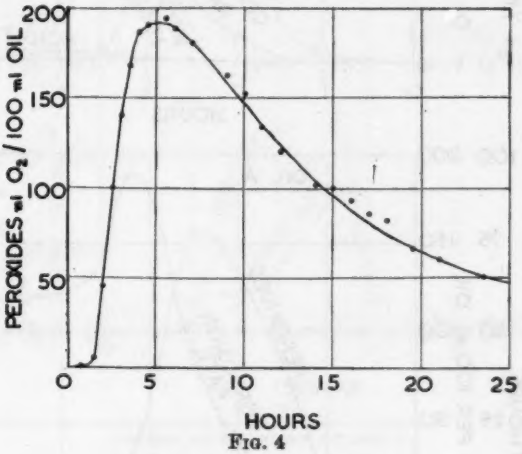

FIG. 4

PEROXIDE CONTENT OF OIL C

results are shown in Fig. 5, from which it will be seen that the peroxide content increased rapidly to a maximum after 2½ hours, then decreased rapidly to a constant low value. Acidity was not detectable until 2 hours had elapsed, and then it increased slowly to the end of the experiment. The rate of corrosion showed an induction period of 1¼ hours followed by a rise increasing in steepness to a maximum after 3 hours, after which it decreased fairly rapidly.

This experiment was repeated, the test pieces being freed of oil by immersing them in benzene, but the deposit was not removed by brushing. The results, which are plotted as a dotted lines in Fig. 5 for oil C, show that the test pieces during the period 1½ to 2½ hours were heavier than when they were inserted in the oil, due to the weight of surface deposit which could be clearly seen at this stage.

The results of tests on oil A are also shown in Fig. 5. Similar curves to those with oil C were obtained, but with higher values for peroxides, acidity, and corrosion rate.

Oil B (Fig. 5) gave much lower values.

With oil A and the air over the oil surface displaced by nitrogen, no corrosion occurred, and no peroxide content or acidity was detected.

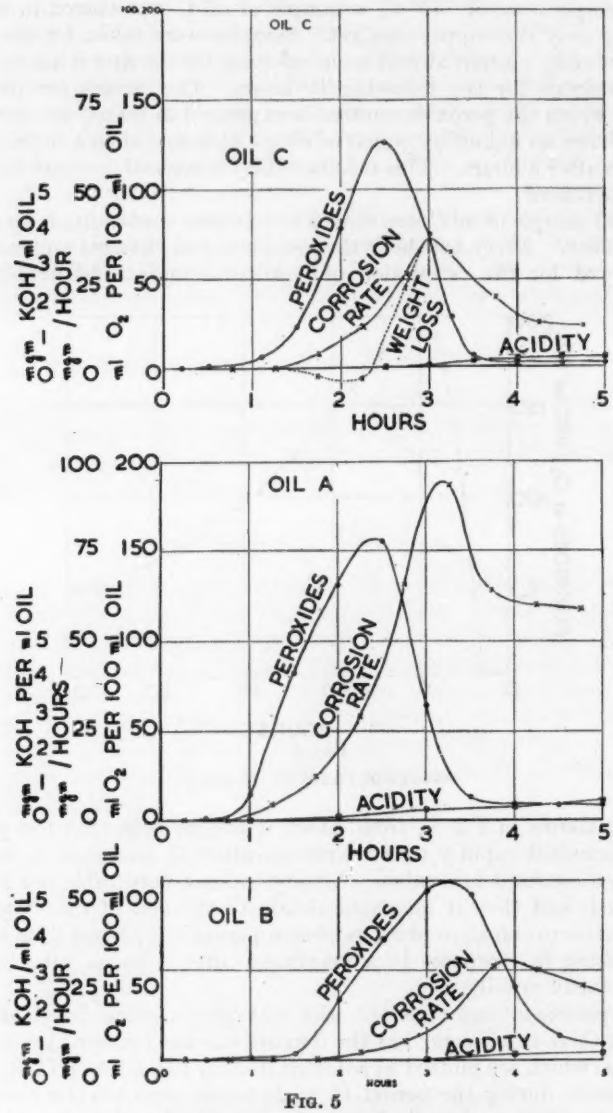

FIG. 5

OXIDATION AND CORROSION CURVES, OILS A, B, AND C

In a further experiment with oil A the air was displaced by nitrogen after 2½ hours from the start. The peroxide content was at its maximum at this period of time. The results, plotted in Fig. 6, show a rapid fall in peroxide content after the nitrogen was introduced, a reduction in the corrosion rate, and no further increase in acidity.

Samples of the yellow deposit produced on the lead surfaces during the

period 1½ to 2½ hours were examined. It contained only 47 per cent lead, and therefore could not be lead oxide (PbO). The deposit was partially soluble in hot dilute hydrochloric acid, and the solution, after the lead ions had been precipitated, was treated with chloroform which extracted minute traces of organic acids. When this chloroform solution was washed down a silica-gel adsorption column it was possible to detect two bands passing down from the top of the column, but they quickly dispersed, and in spite of repeated attempts it was not found possible to separate and collect these acids for identification. The part of the deposit insoluble in hot dilute hydrochloric acid was gummy and sticky, and was found to be soluble in

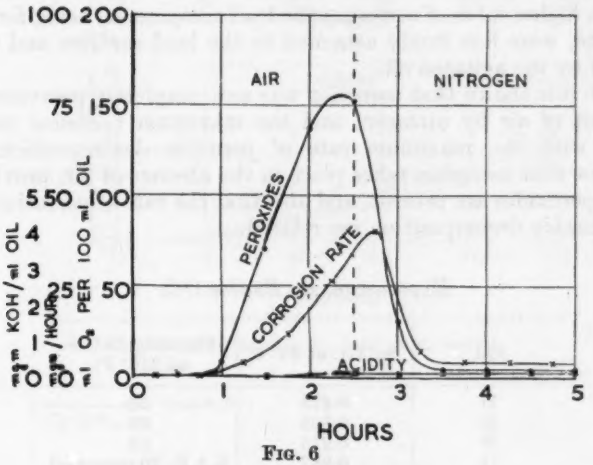

FIG. 6

EFFECT OF NITROGEN ON OIL A

ethyl alcohol, the solution being acid to litmus. The sodium salt of this acid was capable of producing a lather in water. Attempts to purify this organic acid, or acids, were unsuccessful.

RESULTS AND DISCUSSION (WHITE OILS)

Comparison of Figs. 4 and 5 for oil C shows the effect of the presence of lead in the latter. The maximum peroxide content was lower and occurred earlier as a result of interaction of peroxide with the lead. In Fig. 5 the rate of corrosion shows a maximum which occurs when the peroxide content is decreasing at a high rate, and not when the peroxide content is a maximum. The surface deposit producing the increases in weight shown in Fig. 4 is a basic salt and not lead oxide, and therefore the theory, put forward by Denison, that corrosion takes place by the two stages :

(1) $M + AO_2 = AO + MO$; and (2) $MO + 2HA = MA_2 + H_2O$;

where M = metal; AO_2 = peroxide; HA = organic acid, is not supported, although it is not disproved.

The absence of detectable acidity during this period might have indicated

that only stage 1 had taken place, but the presence of acids in the deposit shows conclusively that acids had been generated in the oil but were removed from the oil by the lead.

When the lead test pieces were changed at more frequent intervals, an increase in corrosion rate was found.

Deposit was absent from the test pieces during the period of maximum corrosion rate, and it has been suggested that at this stage the compounds of lead are soluble in the oil. It was noted that when the yellow deposit was no longer visible on the test pieces, the oils became cloudy, although up to this stage they had remained clear. When left to stand it was observed that some yellow powder settled to the bottom of the beakers. This shows that at the higher rates of corrosion the lead compounds, being formed at a greater rate, were less firmly attached to the lead surfaces and therefore washed off by the agitated oil.

In Fig. 6 it is shown that corrosion was not completely prevented by the replacement of air by nitrogen, and the maximum corrosion rate again coincided with the maximum rate of peroxide decomposition. These results show that corrosion takes place in the absence of air, provided that acids and peroxides are present, and also that the rate of corrosion and the rate of peroxide decomposition are related.

Experiments on Engine Oils

Oil	Sp. Gr. at 60° F	Viscosity (S.U.S. at 210° F)
D	0·873	56
E	0·899	60
F	0·915	55
G	0·887	S.A.E. 30 motor oil

" Continuous " Oxidation

A 250-ml sample of each oil was stirred at 160° C in a beaker containing a lead test piece and a copper catalyst. At 3-hour intervals the test piece and catalyst were changed and samples of oil extracted for the estimation of peroxide content and acidity. The results for oils D, E, and F are plotted in Fig. 7. The peroxide content increased rapidly at first and then more slowly, gradually approaching a constant value. Acidity rose at an increasing rate throughout the experiment, and the corrosion rate also increased rapidly at first, and less rapidly later.

" Interrupted " Oxidation

The removal of samples for analysis tended to uncover the lead and copper strips, and the procedure illustrated in Fig. 8 was used.

Four 250-ml samples of the oil were labelled I, II, III, and IV.

(*a*) Sample I was heated and stirred for 6 hours in the presence of a lead test piece and a copper catalyst. Every hour the test piece and catalyst were changed and samples extracted for the estimation of peroxide content and acidity.

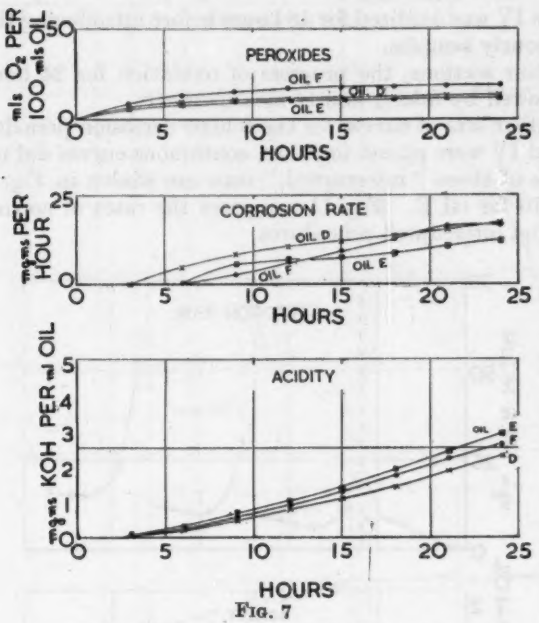

FIG. 7

CONTINUOUS OXIDATION, OILS D, E, AND F

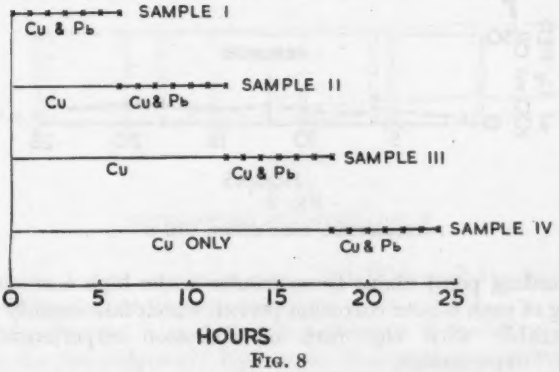

FIG. 8

INTERRUPTED OXIDATION, EXPLORATION DIAGRAM

Test piece changed and samples extracted for acidity and peroxide estimation

(*b*) Sample II was heated and stirred in the presence of a copper catalyst only for 6 hours, then a test piece was introduced and the oxidation continued for a further 6 hours, changing the test piece and taking samples hourly as in (*a*).

(*c*) Sample III was oxidized for 12 hours with only the catalyst strip present before introducing the test piece and continuing the oxidation for a further 6 hours, changing the test pieces and extracting samples hourly.

(*d*) Sample IV was oxidized for 18 hours before introducing the test piece and taking hourly samples.

Thus, in four sections, the progress of oxidation for 24 hours or more could be followed by taking hourly measurements.

When the four sets of curves for the 6-hour corrosion periods of samples I, II, III, and IV were placed together, continuous curves did not result.

The effects of these "interrupted" runs are shown in Fig. 9 for oil D and in Fig. 10 for oil E. Fig. 11 compares the rates of corrosion by the continuous and interrupted procedures.

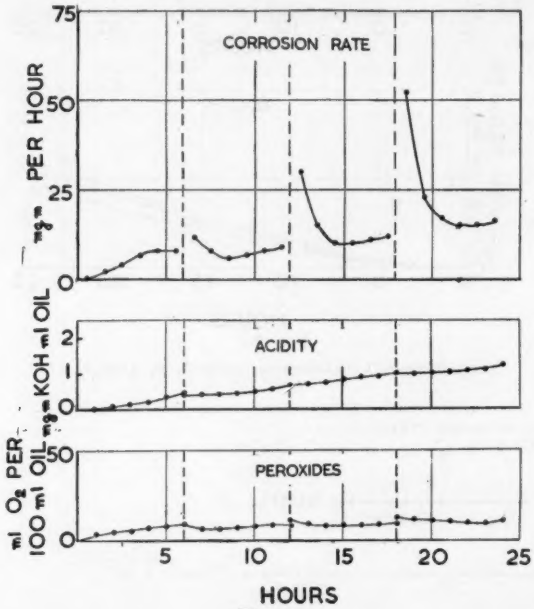

FIG. 9

INTERRUPTED OXIDATION, OIL D

The outstanding point about these results is the high corrosion rate at the beginning of each 6-hour corrosion period, which falls rapidly to a value more comparable with the rate of corrosion experienced in the "continuous" experiments.

Samples of oils D, E, F, and G were each oxidized for 24 hours with only catalysts present. Test pieces were then introduced and the oxidation continued for a further 6 hours, test pieces being changed and oil samples extracted hourly.

RESULTS AND DISCUSSION (ENGINE OILS)

Fig. 7 compares the development of acidity, corrosion rate, and peroxide content of the three oils D, E, and F. It is interesting to note that oil E developed the highest degree of acidity, but showed the lowest peroxide

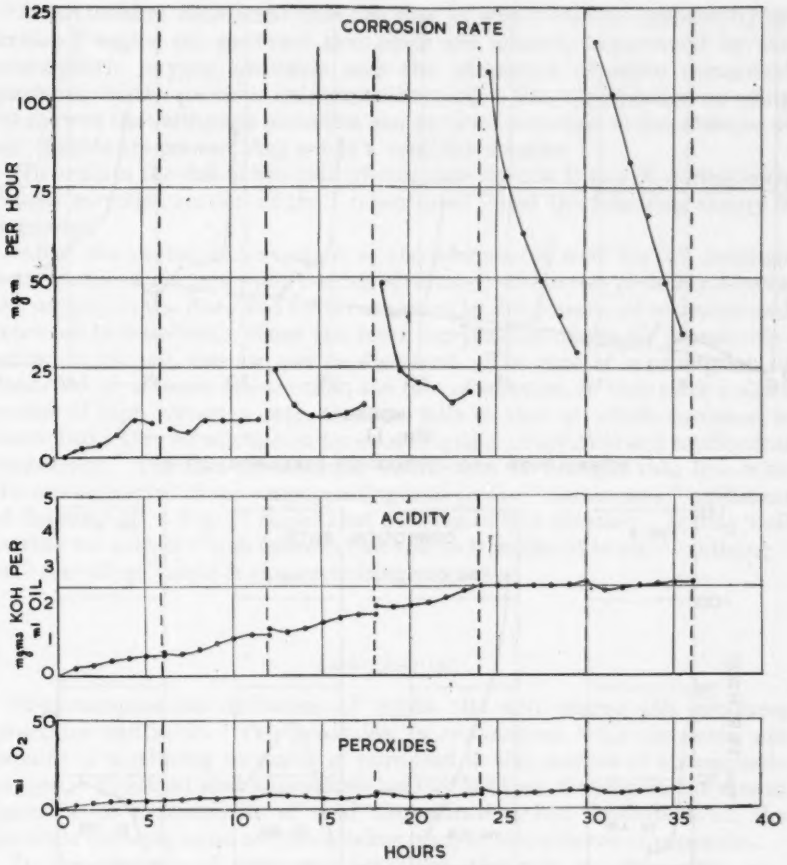

FIG. 10

INTERRUPTED OXIDATION, OIL E

content and the lowest corrosion rate. Oil D showed the highest rate of corrosion but the lowest degree of acidity.

In the "interrupted" oxidation experiments it is difficult to find an explanation for the extremely high rates of corrosion experienced by the first lead test piece of each section. Evidently some compound is formed in the oil during its earlier oxidation in the absence of lead, which is responsible for corrosion, and which, during the continuous run was kept at a reduced value by the presence of lead test pieces. In the second hour of each section the effectiveness, or the properties, of this compound has been reduced by about half and continues to be further reduced with time. It would appear from the acidity and peroxide curves that this compound is neither an acid nor a peroxide. The introduction of nitrogen over the oil surface resulted in the reduction of corrosion rate to an almost negligible amount. (Fig. 12.)

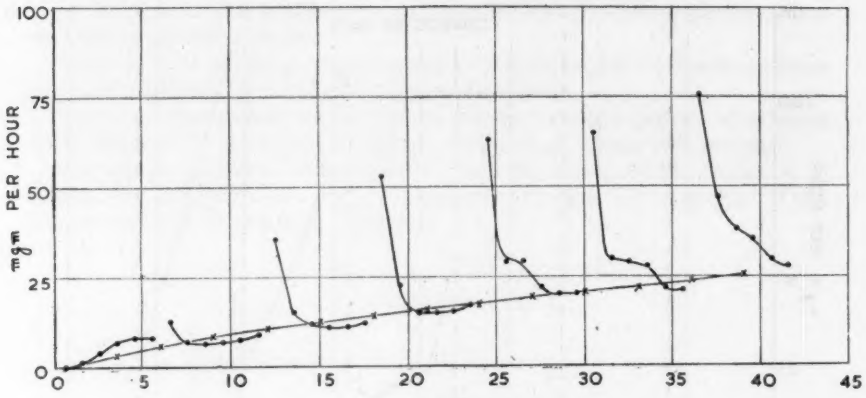

FIG. 11

INTERRUPTED AND CONTINUOUS CORROSION, OIL D

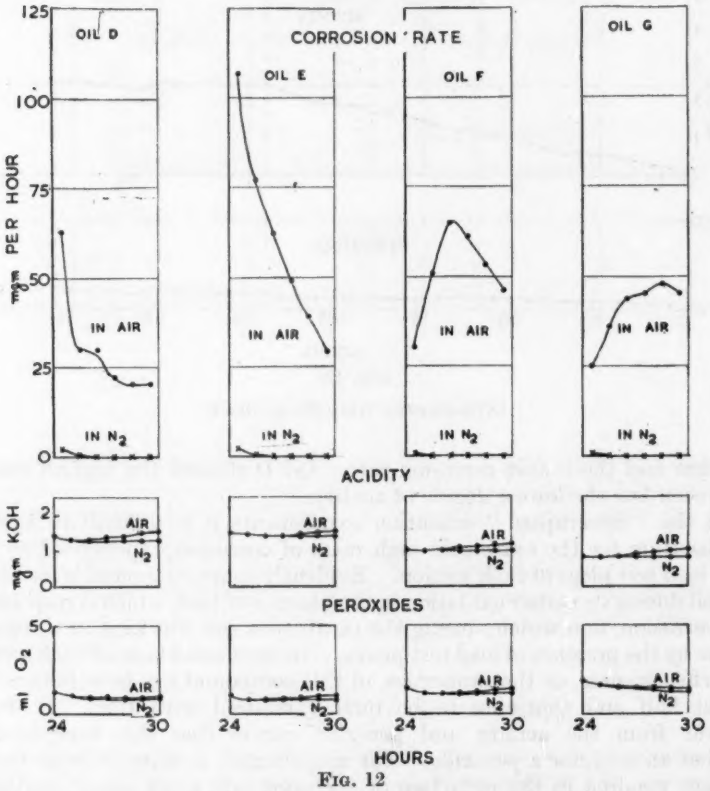

FIG. 12

EFFECT OF NITROGEN ON OILS D, E, F, AND G

It is therefore considered that the rate at which lead is corroded by an oxidized engine oil, provided that acids are present, is governed by the atmospheric oxygen available and the properties of some compound produced by the previous oxidation of the oil. The experiments on white oil showed that although peroxides can produce corrosion in the absence of air, if acids are present they act in a catalytic manner.

To explain the fall in the rate of corrosion by oils D and E during each 6-hour corrosion section of the " interrupted " test the following theory is suggested.

After the period of oxidation in the absence of lead the oil becomes saturated with air, and when stirring is resumed with a test piece in position, the oxygen in the dissolved air is consumed by the process of corrosion and more air is dissolved. Since the inert components of the air remain dissolved in the oil, less air can be dissolved. The rate of consumption of dissolved air is much greater than the rate of solution, so that after a short period of high corrosion rate, the rate falls to that at which corrosion is controlled either by solution or by a combination of solution and mechanical contacting. The rate of corrosion would thus be brought into line with the corrosion rate at the corresponding time in the " continuous " oxidation of the same oil. Fig. 11 shows that this was in fact the case. It may well be that the rate at which dissolved air can be transferred to an " oxidizing " or " corroding " state is the controlling property.

Conclusions

High-temperature oxidation of white oils and engine oils produces peroxides and acids. The peroxides, in conjunction with the acids, are capable of producing corrosion of pure lead in the absence of atmospheric oxygen. Provided that appreciable acidity has been developed, the rate of corrosion is independent of acid concentration but dependent on the peroxide content, as no corrosion takes place in the absence of peroxides.

In the presence of acids and peroxides, the rate of corrosion is considerably influenced by the presence of atmospheric oxygen, and it is suggested that the concentration of atmospheric oxygen in the oil in conjunction with the peroxide content controls the rate of corrosion. For the engine oils, the concentration of atmospheric oxygen had the greater influence, and for white oils the peroxide concentration had the greater influence.

The theory put forward by Denison explaining the mechanism of the corrosion of metals by oxidized oils in two stages has not been proved, and it has been shown that the production of a deposit on the metal surface before acidity is detectable cannot be used to support the theory, since the deposit is not metal oxide.

The work has shown the importance of peroxides and atmospheric oxygen in the mechanism of corrosion, thus supporting the theory that the metal is oxidized before reacting with the acids, but the exact mechanism has not been explained. The metal may be oxidized by atmospheric oxygen catalysed by the peroxides present, or it may be oxidized by the peroxides themselves, which are then regenerated by the atmospheric oxygen. The

fact that the maximum rate of corrosion in white oils coincides with the maximum rate of peroxide decomposition would appear to indicate that the metal is oxidized by the peroxides.

References

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[2] Prutton, C. F., and Day, J. H. *J. Phys. & Colloid Chem.*, 1949, **53**, 1101.
[3] Prutton, C. F., Frey, D. R., Turnbull, D., and Dlouky, G. *Industr. Engng Chem.*, 1945, **37**, 90.
[4] Larsen, R. G. *Anal. Chem.*, 1948, **20**, 547.
[5] Loane and Gaynor. *Industr. Engng Chem.* (*Anal. Ed.*), 1945, **17**, 89.
[6] Wagner, C. D., Smith, R. H., and Peters, E. D. *Anal. Chem.*, 1947, **19**, 976.
[7] Wheeler, D. H. *Oil and Soap*, 1932, **9**, 89.
[8] *Second Interim Report of Oxidation Panel of Standardization Sub-Committee No. 6.*

DEHYDROGENATION OF TETRAHYDRO-THIOPHENE

By Walter Friedmann *

Summary

By dehydrogenating tetrahydrothiophene with the aid of sulphur under pressure, thiophene was obtained; it was identified by means of the characteristic complex salt $Ni(CN)_2 \cdot NH_3 \cdot C_4H_4S$. The formation of a mercaptothiophene can be assumed. The presence of the β,β_1-dithienyl was established and the product identified as one previously synthesized, m.p. 132° C.

Following an investigation [1] of "Dithionethiophanes," in the course of which the two isomeric thiophane derivatives $C_8H_{12}S_3$ were isolated, it seemed advisable to study the reaction between tetrahydrothiophene C_4H_8S and sulphur.

For the preparation of the thiophane, cyclization of 1 : 4-dichlorotetramethylene was effected in aqueous medium with a large excess of sodium sulphide and a reflux time of 24 hours. Only 50 per cent of the theoretical yield was obtained, a heavy oil remaining in the flask after recovering the thiophane by steam distillation. (This work was carried out in October 1948, before the investigation "Cyclic Sulphides," by Whitehead, Dean, and Fidler, was published.[2]) The compound was purified through the mercuric chloride complex, regenerating the thiophane from this derivative with dilute hydrochloric acid and by steam distillation. Physical properties of the dry product were: b.p. $_{575}$ — 115·5/16° C; d_{25} — 0·9923; n_D^{25} — 1·4958.

First, the thiophane (50 cc) and sulphur (18 g) were heated under reflux up to 36 hours, only a very faint evolution of hydrogen sulphide being noticed. On cooling the thiophane solution in an ice–salt mixture, the dissolved sulphur separated, but the redistilled solution did not show any colour reaction with concentrated sulphuric acid and isatin.

After this, thiophane (50 cc) and sulphur (9 g) were heated under pressure; a modified Parr-bomb, with manometer and provision for a thermometer, served as autoclave. It must be borne in mind that the walls of the bomb exert a strong catalytic effect and, therefore, a certain amount of decomposition is inevitable.

The autoclave was heated rapidly up to 160° C, whereupon the pressure rose to 18 atm; the heating was continued for 10 hours at 160° C. The following morning the bomb was at room temperature with 3 atm pressure. The hydrogen sulphide was blown off and the reaction product filtered and thus separated from the decomposed portion. Only 40 cc of product were recovered, indicating a loss of 20 per cent by carbonization. The filtered product was agitated with a dilute solution of alkali, washed with water, and dried.

On distillation the main portion (37 cc) was passed over between 85° and

* Petroleos Mexicanos, Mexico, D.F.

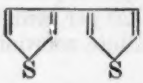
125° C; the remaining residue was distilled from a 5-cc flask; the temperature rose rapidly to 185° C, only a few droplets coming over, and then over the range of 220/240° C, a compound passed over which solidified in the tube of the flask.

The main fraction was distilled through a 20-plate column, when 2·6 cc of material (d_H^{25}, 1·0) came over at a column-head temperature between 80° and 90° C. This product shows a beautiful blue colour reaction with sulphuric acid and isatin, so that the presence of C_4H_4S was proved; it was further confirmed by the formation of the characteristic complex salt $Ni(CN)_2.NH_3.C_4H_4S$.

Regarding the exceedingly small quantity of the second portion, its very unpleasant odour hinted at the presence of a mercaptan, especially as the small extract obtained from the acid-decomposed alkali solution, mentioned above, exhibited the same unpleasant odour. For the characterization of the supposed mercaptan, a mercury mercaptide was prepared, but the precipitate, dried on a porous plate, remained sticky and did not show a sharp melting point. This second fraction also reacted with 2 : 4-dinitrochlorobenzene.[3] However, the starting material was not sufficiently pure to furnish a 2 : 4-dinitrophenyl thioether with a sharp m.p. Nevertheless, the assumption that a thienylmercaptan is formed in the course of the reaction of the thiophane or a partially dehydrogenated thiophane with sulphur or hydrogen sulphide is justified. On dehydrogenating *cyclo*hexane with sulphur, the author has obtained thiophenol.[4] Reasoning from this finding, the assumption is not far-fetched that the dehydrogenation of thiophane with sulphur likewise yields a mercaptothiophene, which is in agreement with the fact that in the technical synthesis of thiophene, starting from butane and sulphur [5] a mercaptothiophene has been separated from the fresh tars by steam distillation or by pyrolysis of the tars. The latter also leads to thiophene and 3 : 4-dithionethiophane. It was expected that the reaction product would contain a member of the latter class in accordance with the behaviour of the thiophane $C_8H_{16}S$ towards sulphur, leading to the dithionethiophane $C_8H_{12}S_3$.[1] Instead of a dithione compound, however, the solidified product mentioned above passed over as the last fraction, which after repeated recrystallization from methanol had m.p. 128° C. The micro-analysis (by Dr C. Tiedke, New York) showed a sulphur content of 39·63 per cent; after further recrystallization the m.p. rose to 132° C, and the micro-analysis gave :—

	3·61% H	57·60% C	38·73% S
Mol. wt. (av. 167)	162	166	172
Mol. wt. of $C_8H_6S_2$ (dithienyl) . .	166	—	—
Anal. calcd for $C_8H_6S_2$ . . .	3·61% H	57·83% C	38·55% S

This product, formed by self-coupling of the thienyl radical has been synthethized before by Auwers and Bredt [6] :



Dithienyl, m.p. 132° C, gives an intense blue colour reaction with concentrated sulphuric acid and isatin.

The presence of β, β′-dithienyl, points to 3-mercaptothiophene as by-product in the dehydrogenation of thiophane. However, as dehydrogenation is often associated with isomerization, one ought to abstain from definite conclusions as to the structure of the dehydrogenated compounds.[7]

Possibly, in the thiophane synthesis from butane at 565° and sulphur at 675°, the first stage is the formation of tetrahydro-thiophene, which goes on reacting with sulphur, yielding dithionethiophane; simultaneously, the dehydrogenation of the thiophane takes place producing mercaptothiophane, mercaptothiophene, and as main product thiophene.

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1 *J. Inst. Petrol.*, 1951, **37**, 40.
2 Division of Petroleum Chemistry, American Chemical Society, Spring 1950.
3 Bost, Turner, and Norton. *J. Amer. chem. Soc.*, 1932, **54**, 1985.
4 *Petrol. Zeit.*, 1916, **9**, 978; *Ber.*, 1916, 1345.
5 *Industr. Engng Chem.*, 1946, **38**, 376.
6 *Ber.*, **27**, 1741–7.
7 Friedmann. *Brenn.-Chem.*, 1927, **8**, 259.

NOTE ON DIMETHYL-DITHIENYL

By Walter Friedmann *

Some time ago experiments were reported on the interaction of hydrocarbons and sulphur under pressure,[1] and it was concluded that: (1) from normal hydrocarbons and sulphur thiophene and thiophthene derivatives are formed and (2) from branched hydrocarbons (such as 2 : 2 : 4-trimethylpentane) thiophanes, sulphides, and dithionethiophanes are produced,[2] while (3) symetrically branched hydrocarbons, like di-*iso*amyl, yield thiophenes and dithienyls.

Referring to the reaction between di-*iso*amyl and sulphur, a re-examination of the product boiling at 260° to 265° C, thought to be a dimethyldithienyl, m.p. 73° C, seemed advisable, because, in the meantime, Sease and Zechmeister [3] have determined the molecular extinction coefficients for some α-bi- and tri-thienyls, etc.† The data thus obtained enabled these investigators to identify a blue fluorescing compound isolated in pure crystals from the petals of the African lemon as an α-terthienyl $C_{12}H_8S_3$—the first time thienyls have been found in a plant organism.

The 260° to 265° C fraction mentioned above was purified by various recrystallizations from solvents, but a better result was obtained by sublimation of the white needles, m.p. 72/73° C. The latter gives a transparent blue colour when treated with isatin and concentrated sulphuric acid, the indophenin reaction typical of the thienyl radical. Analysis: S, 33·27 per cent; Mol. wt., 189, 192. $C_{10}H_{20}S_2$ requires S 32·99 per cent; Mol. wt., 194.

The compound was dissolved in alcohol and treated with aqueous mercuric chloride solution, whereupon a micro-crystalline mercuric chloride immediately separated; it was recrystallized from a mixture of benzene and acetone (1 : 1). On heating, the crystals gradually decomposed above 180° C.

The bromination of the compound m.p. 72/73° C has been described before.[1]

Two samples of the product 72/73° C, marked D and E, were sent to the Universal Oil Products Company for infra-red and ultra-violet examina-

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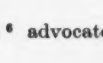
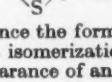
* Petroleos Mexicanos, Mexico, D.F.

† The experimentally proven isomerization of *n*-octane to branched octanes when heated alone for 72 hours at 280° C justified assigning to the dimethylthiophthene (formed in the reaction of *n*-octane with sulphur), the structure [4]:  (*a*)

Other possibilities for the structure of the thiophthene exist, as pointed out by Challenger and Harrison in their investigations "The Isomeric Thiophthenes," [5] *i.e.*, (*b*) and  (*c*). Lately, Wesley Hornton [6] advocated the structure (*b*)—"Since the formation of this compound (structure (*a*)) would involve a highly improbable isomerization of the hydrocarbon skeleton"—a statement which has more the appearance of an opinion than of a definite proof.

tion, and by courtesy of Dr G. Egloff and Dr W. L. Gallaway the absorption spectra were carried out in their laboratory.

Interpreting the determined curves (Fig. 1) of the ultra-violet absorption spectra, Dr Gallaway states the following : " Materials D and E contain the same compounds or chromo-phoric groups to nearly the same extent. The ultra-violet bands of the latter two resemble those given by Sease and Zechmeister for bithienyls."

" The crystals D and E were found, by infra-red examination to be practically identical."

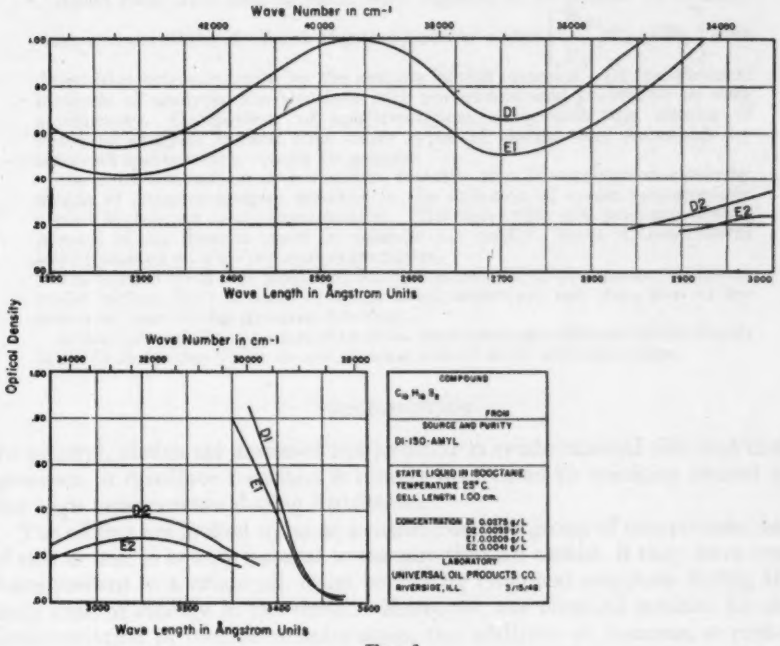


FIG. 1

CURVES FOR DIMETHYL-DITHIENYL

Sease and Zechmeister have established the following molecular-extinction coefficient (maxima) :—

	mμ.	Mol, 1 cc × 10^{-4}
Thiophene	231	0·56
α-Bithienyl	301	1·23
α-Terthienyl	350	2·31
1-Methyl-α-thienyl	355	2·41
1 : 8-Dimethyl-α-thienyl	359	2·61

Naturally, comparing the curves for the dimethyl-bithienyl with those for the bithienyl one has to consider that the introduction of each methyl group shifts the position of the main extinction maximum towards longer wavelengths by 4 to 5 mμ.

However, the question does not seem to be settled whether the products m.p. 72/73° are α- or -β-bithienyl derivatives.

References

[1] *Refiner*, 1941, **20**, 405.
[2] *J. Inst. Petrol.*, 1951, **37**, 40.
[3] *J. Amer. chem. Soc.*, 1947, **69**, 270–5.
[4] *Ber.*, 1916, **49**, 1349.
[5] *J. Inst. Petrol. Techn.*, 1935, **21**, 137.
[6] *J. Org. Chem.*, 1949, 767.

INVESTIGATION INTO THE OLEFINIC COMPONENTS OF A PENNSYLVANIAN CRUDE OIL

F. A. Haak and K. van Nes *

Summary

Apart from *trans*-olefins, which were reported to be present in Pennsylvanian crude oils by Fred and Putscher,[2] also α′ olefins $\left[\begin{matrix}R_1\\R_2\end{matrix}\!\!>\!C = CH_2\right]$ were detected spectroscopically by the authors in this material. Of the chemical methods of analysis, the titration with perbenzoic acid proved to be very satisfactory. Comparison of spectroscopical data with the results of chemical analysis showed that other types of olefins—not detectable by infra-red spectroscopy—must be present.

Careful fractionation of a distillate fraction of a Pennsylvanian crude by means of chromatography resulted in the isolation of cyclic non-aromatic olefins in 100 per cent concentration. The non-cyclic non-aromatic olefins present in this fraction could be isolated only partly; most of these olefins were obtained as a 45 per cent concentrate.

The olefins from this distillate fraction consisted of di-, mono-, and non-cyclic olefins, their average cyclicity being somewhat less than that of the saturated part of the distillate fraction.

It was proved that the majority of at least the *trans*-olefinic double bonds occur in molecules which do not contain one or more aromatic rings.

Introduction

In general, olefins are assumed not to occur in crude mineral oils, and their presence in distillate fractions is mostly attributed to cracking caused by the high temperature during distillation.

The olefins are looked upon as a rather reactive group of compounds, and if this is true it is only natural to assume that all olefins, if they have ever been present in a crude oil, must be lost by chemical reactions during the long time of storage in the earth. Moreover, the classical method for the determination of olefinic unsaturation, the addition of bromine, is rather unreliable, especially when aromatics are present. The bromine numbers found for crude oils and their distillation products were therefore generally interpreted as caused by substitution. In this way the idea that no olefins are present in crude oils was maintained,[1] in spite of an occasional reference to their presence.

Only in recent years, as analytical methods and their application to petroleum products developed considerably, could the problem of the occurrence of olefins in crude oils be investigated more thoroughly.

Fred and Putscher [2] showed the presence of trans-olefins in Pennsylvanian crudes and distillate fractions by means of infra-red spectroscopy: convincing evidence was given that the absorption in the 10·3-mμ region was indeed due to this type of olefins. For a certain Pennsylvanian crude they found that the fraction of the C-atoms linked as *trans*-olefinic bonds was roughly constant throughout a series of distillate fractions (about 1 bond

* Koninklijke/Shell-Laboratorium, Amsterdam.

out of 140 was found to be olefinic). Although the investigation of Fred and Putscher has firmly established the occurrence of olefins in Pennsylvanian crude oils, little is yet known about their nature. From the results published by these authors the impression is gained that the olefinic bonds (at least the *trans* bonds) are distributed at random among the available non-aromatic carbon–carbon bonds.

In the present article an attempt is described to find out more details about the general structure of the olefins occurring in Pennsylvanian crudes. One crude was investigated thoroughly.[3] The following questions will be dealt with :—

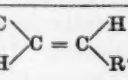
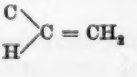
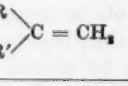
1. *How are the olefinic double bonds distributed among the molecules; do they occur in non-aromatic molecules only, or both in aromatic and non-aromatic molecules?*
2. *Are the olefinic double bonds concentrated in a comparatively small number of molecules, each containing more than one double bond, or does in general only one double bond or less occur per molecule?*
3. *Do the olefins include types other than the trans-type described by Fred and Putscher?*
4. *Is the general structure of the non-aromatic olefinic molecules equal to that of the saturated molecules* (e.g., *is the average number of naphthenic rings of these olefins the same as that of the saturateds)? This would be expected if the distribution of double bonds were perfectly at random.*

Spectroscopical Investigations

Of all types of olefins, only a few can be detected in complicated mixtures by means of infra-red spectroscopy. These types are listed in Table I; they have absorption bands which are specific enough to be recognized as a group in petroleum products.

Table I

Types of Olefins Detectable by Infra-red Spectroscopy

Symbol	Type	Spec. abs. band in mμ
trans		10·3
a		10·0 and 11·0
a'		11·3

In addition to the work of Fred and Putscher, a number of crudes of different origin were investigated by the authors. Some of the non-American crudes contained traces of spectroscopically detectable olefins, of which the *trans*-type predominated; the *a*-type was absent from all crudes investigated. The amount of *trans*-olefins occurring in the Pennsyl-

vanian crude was exceptionally high, in accordance with the experience of Fred and Putscher. This crude was distilled carefully into a series of fractions, keeping the bottom temperature as low as practically possible (below 300° to 330°), in order to avoid cracking and thus the possible production of olefins. The concentrations of double bonds of the *trans*- and *a'*- types were nearly constant in all the distillate fractions. Moreover, these concentrations equalled those in the crude which proves that during the distillation no olefins were formed. The results are given in Table II, and are quite analogous to those reported by Fred and Putscher. As in all these cases the backgrounds in the infra-red-absorption spectra were complicated, the concentrations given in the table are based on the assumption that the backgrounds in the two absorption regions are completely smooth.

TABLE II

Double Bond Concentrations (in mol. equiv/l) in the Distillate Fractions of Pennsylvanian Crude *

Fraction no.		*trans*	*a'*
Gasoline	2	0·10	—
	5	0·10	—
	8	0·10	⩽0·03
	11	0·10	⩽0·03
Kerosine	I	0·08	⩽0·03
	II	0·09	⩽0·02
Gas oil	III	0·09	⩽0·03
	IV	0·10	⩽0·03
Lubricating oil	V	0·10	—
	VI	0·10	—
Pennsylvanian crude		0·10	⩽0·02
Pennsylvanian crude, completely hydrogenated		⩽0·02	⩽0·03

* The concentrations of *trans*-olefins found here are much lower than those reported by Fred and Putscher (0·10 mol. eq/l means that about 0·2 per cent of the C–C bonds are olefinic; Fred and Putscher found about 0·7 per cent). On the other hand, small amounts of *a'* olefins which were not reported before were found by the authors. These differences may be due to the fact that different Pennsylvanian crudes were investigated.

Contrary to the *trans*-olefins, the *cis*-olefins as a group do not show specific absorption bands, and therefore generally cannot be detected spectroscopically in complicated mixtures. This class is important because the cyclic olefins (*cyclo*hexene and *cyclo*pentene derivatives) are obviously of this type.

It was found that the concentrations of double bonds determined by chemical methods (see next section) exceeded those determined by spectroscopical means. Therefore it is highly probable that types of olefins other than *trans* and *a'* are present in this Pennsylvanian crude. Information about these olefins had to be obtained from chemical methods.

CHEMICAL METHODS OF ANALYSIS

All chemical methods for the quantitative determination of olefins are based on the greater reactivity of olefinic double bonds compared with single and aromatic bonds. In complicated hydrocarbon mixtures, such

as mineral-oil fractions, certainly non-olefinic molecules will occur which contain bonds of about the same reactivity towards a certain chemical as the average olefinic double bond. Moreover, the reactivity of the olefinic double bonds in various olefins will differ greatly in connexion with the structure of the rest of the molecule. Therefore it will be difficult—if at all possible—to find a reagent which reacts quantitatively with all olefinic bonds, and not at all with single and aromatic bonds.

The applicability of the following reagents was investigated :—

(1) addition of nitrogen tetroxide;
(2) oxidation with perbenzoic acid;
(3) addition of ozone;
(4) addition of bromine.

The addition of nitrogen tetroxide has been used extensively in terpene chemistry [4] and also in petroleum chemistry.[5] The method used here is a variation of that of Bond : the nitrosates were removed by preferential adsorption on silica gel.

The reaction with perbenzoic acid and the titration of the excess perbenzoic acid with $Na_2S_2O_3$ were performed in the conventional way.[6] Moreover, the oxygen compounds formed were removed from the oil samples by chromatography. In this way it was possible to check the number of double bonds per molecule : by titration the number of double bonds was determined, and by chromatography of the reaction product the number of molecules that had reacted.

The procedure of the ozonolytic titration is briefly as follows [7] : a gas flow of a constant concentration of ozone in oxygen is contacted with the sample; the amount of ozone used by the sample is a measure for the olefinic unsaturation.

The bromine addition was performed according to IP method 9/42.

The application of these methods to a Pennsylvanian distillate fraction from which aromatics and normal paraffins had been removed (see next section) is summarized in Table III. It is difficult to make a choice between these methods, as up till now little experience with any of them has been gained with respect to oil fractions boiling above the kerosine range. The very good agreement between perbenzoic acid titration and N_2O_4 addition favours one of these two. The perbenzoic acid titration was chosen because it is a very simple method, giving good reproducibility and consistent results.

Detailed Investigation of a Distillate Fraction *

Table II clearly demonstrates that the olefinic bonds are not due to a class of compounds with a limited range in molecular weight. Only one distillate fraction (P_{III}), with a boiling range of 310° to 340° C/760 mm Hg, and a mean molecular weight of 265 was therefore investigated.

All chemical determinations of olefins are disturbed by side reactions with the aromatics. For this reason the aromatics were carefully removed

* For additional analytical details on this fraction see contribution to Third World Petroleum Congress, The Hague, 1951, edited by K. van Nes : "Researches on the constitution of petroleum fractions beyond the gasoline range."

by chromatography. Moreover, the normal paraffins were removed by extractive crystallization with butanone. In this way 30 per cent of the initial oil fraction was removed. The resulting fraction (containing *iso*-paraffins, naphthenes, and olefins only) will be called P III B.

The aromatic part of this distillate fraction could not be shown to contain olefinic double bonds with certainty. All *trans* double bonds from P III were, however, concentrated in P III B : the concentration of the *trans*

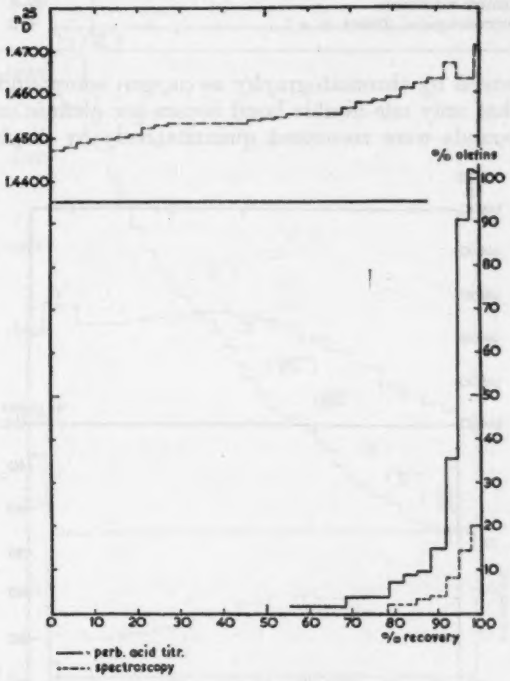


FIG. 1

OLEFIN CONTENT OF THE PERCOLATION FRACTIONS OF P III B

double bonds (determined by infra-red spectroscopy) in P III B (= 70 per cent of P III) being 0·14 mol. eq/l, and in P III itself 0·10 mol. eq/l. So most of the *trans* double bonds certainly occurs in non-aromatic molecules, and it is probable that the same holds roughly for the other types of olefinic bonds.

Another point, viz., that of the occurrence of olefins of other types than *trans* or *a'*, is cleared up by the results given in Table III : the amounts of olefins found by each of the chemical methods considerably exceed the amount found from infra-red absorption.

If the perbenzoic acid titration and N_2O_4-addition are assumed to be the most reliable methods, more than half of the olefins belong to types which were not found spectroscopically.

Finally, the agreement between perbenzoic acid titration and the amount

TABLE III

Percentage Olefinic Molecules in Fraction P III B

Method	% wt
Perbenzoic acid, titration	10·2
Perbenzoic acid, chromatography	10·7
N_2O_4 addition	10·2
Ozonolytic titration	9·3
Bromine addition	7·8
Spectroscopical (*trans* + *a'*)	4·2

of olefins removed by chromatography as oxygen compounds justifies the assumption that only one double bond occurs per olefinic molecule. The oxygen compounds were recovered quantitatively by displacement with

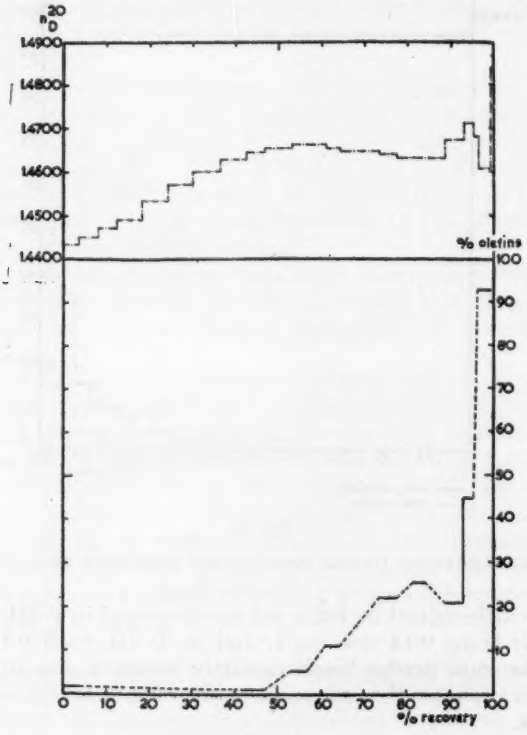


FIG. 2

OLEFIN CONTENT OF THE PERCOLATION FRACTIONS OF THE SECOND PERCOLATION

alcohol; further investigations could not be made because part of the epoxides were hydrolysed to diols.

In order to isolate purely olefinic fractions the fraction P III B (250 g) was fractionated by chromatography (see experimental part).

Fig. 1 shows the results of this fractionation. The olefinic content is

calculated from infra-red absorbency as well as from perbenzoic titrations. Part of the olefins (30 per cent wt = 8 g) was isolated as " 100 per cent pure " olefins; this part is further called " olefin fraction 1." The other fractions containing olefins (from 55 to 97 per cent recovery) were mixed and percolated again through silica gel. This fractionation is summarized in Fig. 2. In this way another 14 per cent of the olefins was isolated as a purely olefinic fraction (" olefin fraction 2 ").

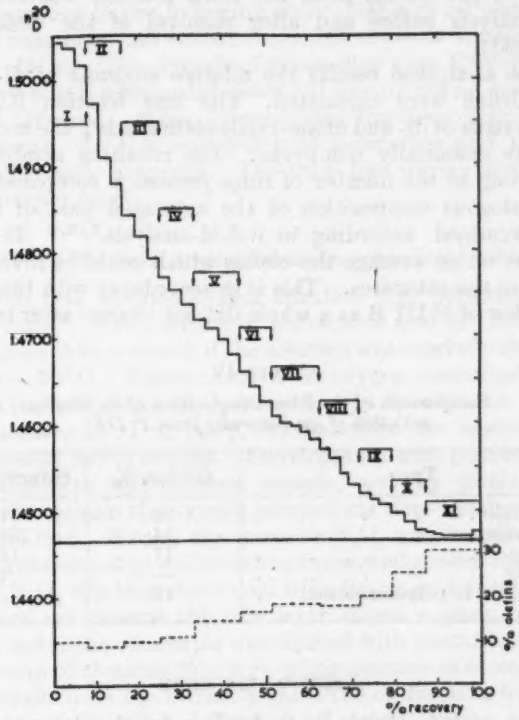


FIG. 3

OLEFIN CONTENT AND REFRACTIVE INDEX OF THERMAL DIFFUSION FRACTIONS

In order to isolate the remaining olefins, thermal diffusion to the middle part of the second percolation was attempted. The idea was that, as these olefins are difficult to isolate by adsorption, they are very likely to contain only a small number of naphthenic rings (if at all), and might be contaminated with highly cyclic napththenes. It is the experience of the authors that thermal diffusion separates roughly according to the number of rings present in the molecule. It was hoped thus to separate these less cyclic olefins from the more cyclic naphthenes. This speculation, however, proved to be incorrect: all thermal-diffusion fractions contained olefins to about the same extent, as is shown in Fig. 3.

The thermal-diffusion fractions were recombined to six fractions, and the olefins in each of them were concentrated by chromatographic analysis.

The fractions rich in olefins were blended, yielding an olefin concentrate containing the last olefins of P III B in a concentration of 45 per cent (called olefin concentrate fraction 3).

From the chromatographic behaviour of the three olefin fractions the first might be expected to consist of the highest cyclic olefins and the third to contain the least cyclic olefins present in the initial distillate fraction. This was fully confirmed by elemental analysis of the three fractions (the composition of the olefins from the third fraction was calculated from elemental analysis before and after removal of the olefins by excess perbenzoic acid).

From these analytical results the relative amounts of di-, mono-, and non-cyclic olefins were calculated. The first fraction ($C_nH_{2n-3.1}$) was assumed to consist of di- and mono-cyclic olefins only; the second and third fractions were essentially non-cyclic. The resulting composition of the olefins according to the number of rings present is compared in Table IV with the analogous composition of the saturated part of this distillate fraction, determined according to n-d-M-analysis.[3, Ch. 4] It is seen from this table that on an average the olefins which could be investigated were less cyclic than the saturates. This is in accordance with the fact that the refractive index of P III B as a whole did not change after removal of the olefins.

TABLE IV

Comparison of the Ring Composition of the Olefins with that of the Saturates from P III

Type	Olefins, %	Saturates, %
Non-cyclic	56	41
Monocyclic	14	37
Dicyclic	17	15
Tricyclic	—	7
Losses (due to polymerization)	13	—

ACKNOWLEDGMENT

The authors wish to thank Dr C. La Lau for the determination of the spectroscopical data and the Management of N.V. De Bataafsche Petroleum Maatschappij for their permission to publish this paper.

APPENDIX

EXPERIMENTAL

1. *Preparation of P III B from P III.*

(a) *Removal of the aromatics.*—About 3·2 kg P III was percolated through silica gel (from Silica Gel Ltd., London, "Sorbsil"), with gel to oil ratio of 3 : 1, in two columns (each containing about 5 kg) of 3 m length and 6 cm diameter. Development with pentane yielded purely non-aromatic fractions, and some intermediate fractions (amounting to 150 g), con-

taining some aromatics also. The intermediate fractions were re-percolated, using the same silica gel, and a gel-to-oil ratio of 10 : 1. In this way a complete separation was obtained between aromatics and non-aromatics. (The intermediate fraction of this second percolation amounted to about 5 g only.) 3192 g of non-aromatics and 442 g of aromatics (displaced from the columns by ethanol and chloroform (1 : 1 mixture)) were obtained. The loss of material was 0·5 per cent only.

(b) *Removal of the* n*-paraffins.*—2400 g of the aromatic-free P III was treated in 8 portions in the following way : 300 g of oil was dissolved in 2·25 litres of butanone and cooled down till crystals appeared (−1° C), and then to −11° C. The crystals of *n*-paraffins were filtered off, and the mother liquor was stepwise cooled down 10° C more till no more crystalline material was obtained. Some intermediate fractions were retreated in the same manner. In this way 563 g of *n*-paraffins and 1816 g of the fraction P III B were prepared. The total loss during these operations was 21 g (= 0·9 per cent).

2. *Determination of the olefin content by various chemical methods.*

(a) *Perbenzoic acid titration.*—This titration was performed along the conventional lines.[6] The solution of perbenzoic acid in $CHCl_3$ proved to be stable for more than a month if the solution was carefully dried, and kept in the dark at − 20° C. The removal of the oxygen compounds by chromatography was realized, using Al_2O_3 (according to Brockmann, Brocapharm, Holland) in a ratio 10 : 1 or more, calculated on the amount of oxygen compounds present in the sample. Development with pentane gave in the filtrate the complete hydrocarbon sample, and by displacement with alcohol from the column the oxygen compounds were obtained.

(b) *N_2O_4 addition.*—Excess dry gaseous N_2O_4 was introduced into the oil sample (in general 1–2 g) while cooling in ice, and shaken for about 1 min. The excess of N_2O_4 was then destroyed with 10 per cent aqueous urea solution. If olefins are present the oily layer shows a green colour. After washing with water the oil sample was diluted with pentane and percolated through a column of alumina (6 to 8 g), using pentane as eluent. Evaporation of the solvent from the filtrate yielded the oil fraction from which the olefins were removed. The difference in weight before and after the treatment gave the amount of olefins present in the sample.

3. *Isolation of the olefins by chromatography.*

(*a*) 250 g of P III B was percolated through 2·5 kg of silica gel (Davison, through 200 mesh).* Column dimensions : length 140 cm, diameter 6 cm. Pentane was used as developer, and this was stripped from the filtrate continuously. Fractions of eluate of about 10 ml were obtained. The results are given in Fig. 1; 7·9 g of "pure olefins" was obtained (olefin fraction 1 : elemental analysis per cent C 86·5, per cent H 13·3; M = 275; Composition $C_nH_{2n-3\cdot1}$). About 1 per cent of this oil fraction could not be

* According to the experience of the authors the absorption affinity to olefin is less for Sorbsil gel than for Davison gel; therefore for the removal of aromatics Sorbsil was used, and for the isolation of the olefins Davison silica gel.

displaced from the column, even with alcohol as displacer. This must be ascribed to polymerization of the olefins.

(*b*) The fractions indicated in Fig. 1 as " intermediate " were recombined (104 g, 5 g was used for the perbenzoic acid titration) and re-percolated through 1·3 kg of Davison silica gel. The same technique was used as in the first percolation. Column dimensions: length 3 m, diameter 3 cm. The results are summarized in Fig. 2, another 3·1 g of olefins was isolated. (Olefin fraction 2; elemental analysis per cent C 85·0, per cent H 14·2; M = 277; composition $C_nH_{2n-0.1}$).

(*c*) Details about the thermal-diffusion procedure will not be given here.[8] The results of the application of this method to the intermediate fractions of the second percolation (see Fig. 2) are given in Fig. 3. No concentration of olefins was obtained in this way.

(*d*) The thermal-diffusion fractions obtained under *c* were percolated through Davison silica gel, using a gel-to-oil ratio of about 30 : 1. The high-olefin fractions from all these percolations were recombined. The concentration of the olefins in this combination fraction was 45 per cent (= olefin concentrate fraction 3; elemental analysis: before removal of olefins per cent C 86·8, per cent H 13·5; after removal: per cent C 87·0, per cent H 12·9; M = 274; composition $C_nH_{2n-0.2}$).

Amsterdam, November 9th, 1950.

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NOTES ON THE LUBRICATING EFFECT OF COLLOIDAL GRAPHITE

By E. A. Smith (Member) *

The subject of these notes is the evaluation of the lubricating action of graphite in the form of dry films and as a colloidal dispersion in oil. Measurements on natural and electric-furnace graphite indicate no noticeable differences, so that the data below could apply to both products. A dominant feature of colloidal graphite is the way it minimizes metal pick-up between sliding surfaces. This is illustrated in Fig. 1, where the wear tracks are shown for : (*a*) unlubricated copper sliding on copper ; (*b*) copper sliding on copper when lubricated with oil containing colloidal graphite. The dark areas on the wear tracks indicate plucking of the surfaces. The calculated load on the sliding member in these experiments was very high, so that the rubbing surfaces have been protected to a marked extent in the second instance. Tests on a Boerlage four-ball machine also show an increase of 30 per cent in the seizure load for graphited oil compared with an SAE 30 mineral oil.

Dry Graphite Films

As the coefficient of friction of graphite on graphite is, generally speaking, of the same order as for metal on graphite, one can accept the values obtained in friction-testing machines as providing a good indication of the inherent lubricity of this additive. Below are quoted data from various machines, in which positive rubbing, reciprocation, and rolling have been used. The three-ball slider is a simple sliding member, supported on three steel balls, which rest upon the graphited surface to be tested for friction. The second instrument mentioned in the table employs a plane metal surface moved to and fro over the graphited test surface by means of an air-actuated ram, the frictional resistance being measured by means of an electrical strain-gauge assembly. The rollers composing the last device in the list were designed so that the conditions encountered in the rolling of strip metal would be simulated.

Table I

	Graphite film	Unlubricated metal	Mineral oil
Three-ball slider	0·09–0·12	0·16–0·18 *	0·15–0·17
Plane slider (reciprocating)	0·15	—	—
Bowden–Leben machine	0·07–0·1	0·4	0·17–0·22
Modified Deeley instrument	0·12	0·6	0·15
Rollers	0·05	—	0·07

* Surfaces washed with oil solvent but not chemically clean.

At first sight, the above values for graphite may appear to exhibit undue spread, but it should be remembered that testing machines will tend to give

* Acheson Colloids Ltd.

characteristic friction values; that is why comparative values for mineral oil are quoted. The reason why a dry film of pure graphite offers lower friction than mineral oil under boundary conditions can be explained by the fact that the boundary oil film enables the substrate metal to assert its friction value, which will be higher than the characteristically lower one of graphite. Where fluid conditions exist, colloidal graphite would not be expected to influence the already low value.

Colloidal Graphite in Oil

From the results obtained with various testing machines, an interesting fact becomes apparent; the friction values for a graphited surface are lower in the presence of an oil than for either the graphite film alone or for the oil alone. This points to a mutual reaction of the oil and the surface on which it lies. The general effect, of course, is well known, as for example, the chemisorption of certain polar lubricants on particular bearing metals. In the case of a graphited surface, the higher adsorptive power of the surface, compared with metal, has led to stronger adsorption of oil, which finds its practical expression in a lower friction value.

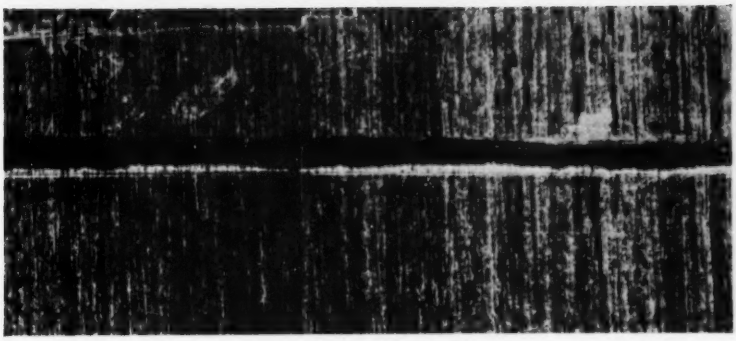
The following are some of the results obtained using a dispersion of colloidal graphite in mineral oil, ranging from 0·2 per cent concentration of the additive in oil to 10 per cent concentration (" Oildag "). In column 2 of Table II is given a brief description of the principle of the machine, and a

TABLE II

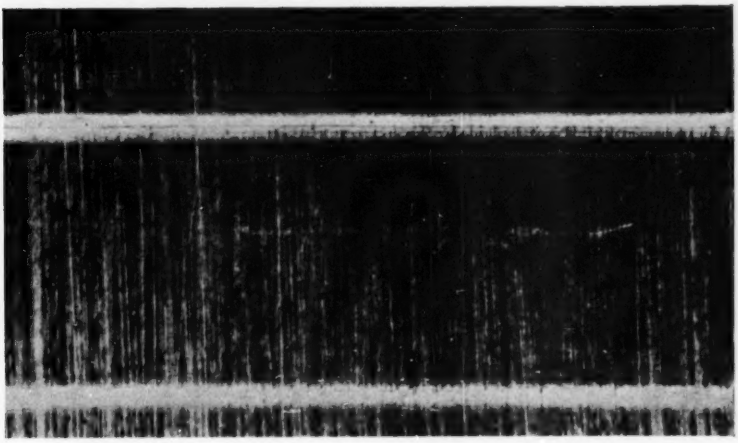
Machine	Description	μ_k Graphited oil	μ_k Mineral oil
Deeley	Plane horizontal disc rubbing against three flat-edged studs arranged in a circle on an upper disc which is free to rotate parallel to the lower disc. Rubbing speed 20 ft/min, pressure 50 p.s.i.	0·04	0·05–0·06
Thoma	Two steel cylinders running against one another on inclined axes, one at 50 r.p.m. and the other at 300 r.p.m. Sinusoidal line contact; load (estimated) 42,000–125,000 p.s.i.	0·075 0·042	0·077 0·045
Bowden–Leben	Cylindrical member resting on a plane surface which is drawn along by hydraulic ram.	0·06	0·08–0·12 *
Cold rolls in sheet-metal working	Polished steel rolls 6 inch dia 20/30 r.p.m. sheet reduction 22%.	0·068	0·082
Journal bearing	Steel journal in white-metal bearing 2 inch dia, 500 r.p.m. Loads 500–2000 p.s.i., 80° C.	0·001	0·001

* Compounded oil.

comparison is made between graphited oil and plain mineral oil. With the exception of the journal-bearing machine, which is included to show what happens under full fluid conditions, all testing is under boundary conditions. It might be interposed here that a fine particle size is required



(*a*) COPPER ON COPPER UNLUBRICATED



(*b*) UPPER TRACK. THICK FILM OF GRAPHITED OIL (50 TRAVERSALS)
(*c*) LOWER TRACK. THIN FILM OF GRAPHITED OIL (3000 TRAVERSALS)

FIG. 1

To face p. 256.

for high rubbing speeds, as indicated by Trillat and Morel,[1] who found that coarse particles as represented by flake graphite failed to lubricate at any but the lowest speeds, due to failure to adsorb to metal.

Effect of Temperature

As the hydrodynamic effect of the oil carrier may mask the performance of colloidal graphite in the above tests, further experiments have been carried out with heated lubricants. Some results obtained on a Bowden–Leben machine are shown in Fig. 2, which illustrates a general effect. The friction value for plain oil rises until the temperature of 180° C is reached,

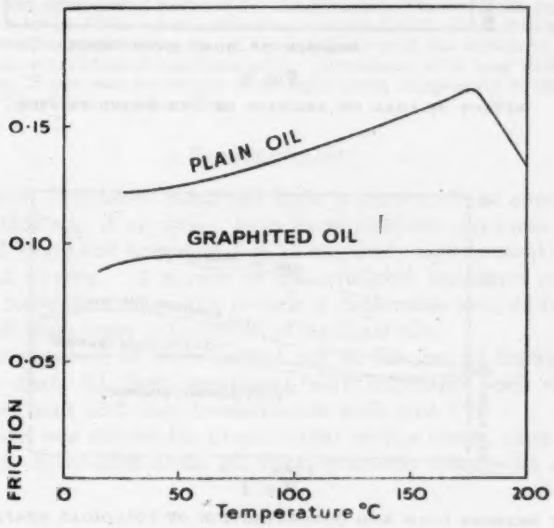


FIG. 2

EFFECT OF TEMPERATURE ON FRICTION

after which it falls. The hump in the curve is considered to be due to desorption of the oil from the metal surfaces on which it lies. Oxidation sets in at 180° C, and as is well known, the resulting products offer good lubrication, such oxidation, however, not being desirable in practice.

Effect of Load

It would seem that the coefficient of friction of a thin, oriented graphite film does not vary appreciably over any limited range of loads, up to the lower values for extreme pressures. In the latter, anomalies appear, which may be due to faulty testing technique. Fig. 3 shows how the friction value for colloidal graphite varies with load. Using a different testing instrument, the results are shown in Fig. 4 in which both the load and the percentage of colloidal graphite in the oil have been varied. It is known that boundary conditions of lubrication prevail throughout the load range in Fig 3.

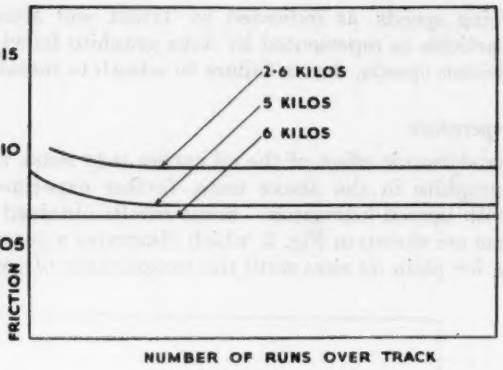


FIG. 3

EFFECT OF LOAD ON FRICTION OF DRY GRAPHITE FILM

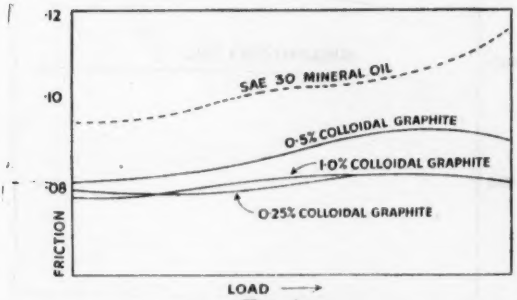


FIG. 4

EFFECT OF BEARING LOAD AND CONCENTRATION OF COLLOIDAL GRAPHITE IN OIL ON FRICTION

Effect of Rubbing Speeds

It is important to appreciate that the maximum action of colloidal graphite in an oil is obtained when an adsorbed graphoid surface has been formed on the rubbing faces of mechanical equipment. Such a surface permits shear of the slippery graphite particles without the underlying metal becoming exposed. This may help to explain the results of Johnson, Godfrey, and Bisson,[2] who found that the coefficient of friction remained constant up to 1000 ft/min, but then increased until it was about 25 per cent higher at 5000 ft/min. The observations of Trillat and Morel, referred to earlier in these notes, should here be kept in mind.

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STUDIES IN SHALE OIL. PART I. SOME PROPERTIES OF THE GAS OIL FRACTION

By G. Nottes and Geo. E. Mapstone (Fellow)

Summary

The gas oil fraction of Glen Davis shale oil has been treated with concentrated sulphuric acid, oleum, and chlorsulphonic acid. Treatment with concentrated sulphuric acid appears to effect an essentially complete removal of olefins and aromatics if followed by distillation to remove olefin polymers. Complete solution of the oil on successive treatment with oleum indicated the normal paraffins by this reagent. Chlorsulphonic acid also dissolved more of the oil than concentrated sulphuric acid. Treatment with urea showed the presence of 27 per cent by weight of straight-chain compounds in the oil, of which 11·7 per cent were paraffins.

Introduction

Compared with petroleum, relatively little is known of the composition of shale oils, which are, if anything, even more complex mixtures because of their thermal origin and history and their relatively high content of sulphur, nitrogen, and oxygen. A review of the available literature on the constituents of Australian shale oils reveals a deplorable lack of information in this field, though more is known of other shale oils.

Results are reported of work carried out on the gas oil fraction of Glen Davis crude shale oil, first, treatment with sulphuric acid, oleum, and chlorsulphonic acid, and then fractionation with urea.[1-4]

This fraction was chosen for examination at this stage, since it is from a similar cut of Scottish shale oil that synthetic detergents are manufactured.[5]

Experimental

Distillation of Crude Shale Oil

Four litres of crude shale oil were distilled from a gas-heated 1-gallon iron still fitted with a simple vapour take-off.

The fractions distilling in the ranges up to 200° C, 200° to 240° C, and 240° to 320° C were collected separately, the average yield of each fraction for three such distillations being 8·2, 11·4, and 18·5 per cent by volume respectively. The properties of these distillates are given in Table I.

Before carrying out any work on it, the gas oil fraction (240° to 320° C) was washed with diluted hydrochloric acid to remove tar bases and then with dilute sodium hydroxide solution to remove tar acids.

Treatment with Concentrated Sulphuric Acid

One hundred grams of the fraction were mixed with good stirring with 100 g concentrated sulphuric acid. The reaction was strongly exothermic, and good cooling was necessary to maintain the sulphonation temperature below 20° C. After half an hour, the mixture was diluted with 30 g of ice

TABLE I

Shale Oil Distillates

Fraction	To 200° C	200° to 240° C	240° to 320° C	Bottoms, over 320° C
Sp. gr. 15·5° C	0·790	0·830	0·850	0·953
°A.P.I.	47·6	39·0	35·0	17·0
Distillation				
10%	154	198	222° C	—
30%	163	202	256° C	—
50%	171	209	278° C	—
70%	179	215	306° C	—
90%	195	228	325° C	—
F.B.P.	214	253	333° C	—
Aniline point	—	—	65° C	—
Bromine no.	6·4	6·0	5·4	9·0
Av. mol. wt.[19]	136	158	209	—
U.O.P. characterization factor K.[19]	11·7	11·5	11·6	

with stirring and cooling. This procedure gave good separation of the reaction mixture into three layers. These were separated and the unreacted oil treated with a further 100 g of acid as above. The treatment was repeated four times, after which the oil was washed with 1*N*-sodium hydroxide solution and then distilled to its original final boiling point to remove polymers. The water-white distillate had a faint naphthenic odour. The results are given in Table II.

TABLE II

Treatment with Concentrated Sulphuric Acid

Products	Treatment					
	Original	First	Second	Third	Fourth	Re-distilled
Oil: Parts by vol.	100	80	56	51	50–55	37
Colour	Dark	Dark	Dark	Dark red	Dark red	Colourless
Sp. gr. (15·6° C)	0·850	—	—	—	0·830	0·810
Aniline point	69° C	—	—	—	87° C	92° C
Bromine no.	5·4	—	—	—	0	0
Sludge, parts by vol.	—	28·5[a]	30[b]	2[c]	nil	—
Sp. gr.	—	1·24	—	—	—	—
Dilute acid, parts by vol.	—	120	122	130	—	—
Sp. gr.	—	1·600	—	—	—	—

When neutralized with sodium hydroxide solution was:

(*a*) Soluble in water to give a milky solution.

(*b*) When neutralized with sodium hydroxide, solution was soluble in water. This solution foamed more than first sludge.

(*c*) Added to sludge from second treatment.

Treatment with Oleum

One hundred grams of the fraction were treated twice with concentrated sulphuric acid as described above, and the remaining oil treated with oleum in the same manner. The (second) treatment with 20 per cent

oleum was repeated a further four times, after which no oil remained. In all cases sulphur dioxide was evolved during the treatment of the oil with oleum. At the end of the reaction 15 g of ice were added with vigorous stirring in order to get good separation of the layers. The results are given in Table III.

TABLE III

Treatment with Oleum

Products	Original	After H_2SO_4 treatment	Oleum treatment	
			First	Second
Oil, parts by wt	100	60	50	19
Colour	—	Dark red	Very dark [a]	Clear colourless [b]
Sp. gr. (15·6° C)	0·850	—	—	0·750 [b]
Aniline point	69° C	—	—	97° C [b]
Acid used, parts	—	2 × 100	40	60
Strength	—	conc.	10% SO_3	20% SO_3
Sludge, parts by vol.	—	—	14	35 [c]
Dilute acid, parts by vol.	—	—	51	[b]

(*a*) The colour of the oil was lightened a little by treatment with a large amount of fuller's earth.

(*b*) After washing with 20% caustic soda solution. Before washing the colour was reddish-yellow.

(*c*) Dark brown sludge, after neutralization with caustic soda showed good surface-active properties in dilute solution.

Treatment with Chlorsulphonic Acid

One hundred grams of the fraction were treated with 40 g of concentrated sulphuric acid as before. To the 90 g of recovered oil, an equal weight of chlorsulphonic acid was added over a period of 2 hours with good stirring and cooling. The addition of the first 60 g of the chlorsulphonic acid was accompanied by the copious evolution of hydrogen chloride. After standing overnight, 36 g of a dark brown oil (sp. gr. 0·809) separated from 122 g of black acid sludge and was removed.

After adding 35 g of ice to the acid sludge with stirring and good cooling, 73 g of tar separated from the dilute acid. This tar was dissolved in dilute caustic soda to give a yellowish solution with surface active properties. Only a few traces of oil separated from this solution on standing overnight.

Formation of Sulphonamides

A stream of ammonia gas was bubbled with stirring, through the 36 g of oil recovered from the treatment with chlorsulphonic acid. After a few minutes the oil became milky and yellowish from the precipitation of ammonium chloride. After an hour no sulphochloride odour remained, and the reaction mixture was just brought to the boil twice with an equal volume of 1*N*-sodium hydroxide and once with water. These three washes were combined, acidified with sulphuric acid, and the liberated oil extracted with ether. Evaporation of the ether on a water-bath yielded 1 g of sulphonamide as a yellow-brown, very viscous oil with sp. gr. 1·002, and nitrogen content (Kjeldahl) 4·24 per cent (calc for $C_{15}H_{31}SO_2NH_2$ 4·35 per cent). It

was soluble in hot 1*N*-sodium hydroxide, from which solution it was re-precipitated by acids. It was also soluble in methanol, ethanol, benzene, acetone, and chloroform.

Treatment with Urea

One hundred grams of the fraction were mixed with 300 g of urea and 500 g of methanol. After stirring at 22° C for 1 hour, the crystalline mass was filtered by suction and the filter-cake washed twice with 350 g of ice-cold methyl ethyl ketone. The residual solid was decomposed with 700 ml of hot water, and the separated oil was heated on a boiling water-bath and finally blown with steam for a few minutes to remove the final traces of methyl ethyl ketone. Yield: 27 g of a yellowish-brown oil.

The methanol–methyl ethyl ketone filtrate and washings were bulked and evaporated on a steam-bath, the last traces of the solvents being removed by blowing with steam. Yield: 73·3 g of a dark-coloured oil.

Both fractions were treated twice with a three-fold amount of concentrated sulphuric acid as described previously, and the treated oil redistilled to the final boiling point of the initial sample (330° C) to remove olefin polymers. The yields and analyses of the oils are given in Table IV.

TABLE IV

Fractionation of Oil with Urea

Sample	Original	Urea adduct			Residue from adduct		
		Initial	Acid treated	Re-distilled	Initial	Acid treated	Re-distilled
Weight %. .	100	27·0	17·3	14·7	73·3	30·8	23·4
Sp. gr. at 60° F .	0·850	0·720	0·78	0·72	0·894	0·860	0·87 [a]
Volume . .	100	31·9	18·7	17·4	69·6	30·4	22·9
Aniline point, ° C	65	93	102	101	36	75	—
Br. no. . .	5·4	6·5	0	0	5·1	0	0

(*a*) Sample accidentally lost before complete characterization so sp. gr. calculated from 0·72 sp. gr. of *n*-paraffins (above) and 0·810 sp. gr. for total paraffins plus naphthenes (Table I).

The normal paraffins from the urea adduct were colourless and almost odourless, while the *iso*paraffin–naphthene oil was a bright colourless oil with a typical naphthenic odour.

In each case the sulphonates, etc., in the acid used for the treatment showed surface-active properties after neutralization.

DISCUSSION OF RESULTS

When a hydrocarbon mixture is treated with concentrated sulphuric acid, a very complex series of reactions can take place, depending on the composition of the oil and the reaction conditions. The reactions taking place will be the same as those involved in the acid treatment of gasoline, though the greater average molecular weight and complexity will tend to modify the extent and direction of the reactions.[6] Exhaustive treatment

with sulphuric acid would remove all aromatics by sulphonation, and all olefins by sulphation, polymerization, and similar reactions. Distillation of the oil to its original final boiling point after exhaustive treatment with concentrated sulphuric acid gave 37 per cent by volume of saturated paraffins and naphthenes as compared with 40·3 per cent by the same technique after fractionation with urea. It is probable that a small proportion of the paraffins and naphthenes was oxidized and thus removed by the acid, so these figures would tend to be somewhat low.

Even though the fourth concentrated sulphuric acid wash removed only 1 per cent by volume of the oil, 20 per cent oleum continued to attack the oil until it was completely dissolved. Since the solubility of paraffins in sulphuric acid increases with both their molecular weight and the acid strength,[7, 8] this may be partly due to physical solubility effects, though oleum has been reported to attack the higher paraffins slowly at room temperature with the formation of aliphatic sulphonic acids,[9, 10] and the results obtained in this work are best explained by such oxidation.

The ready evolution of hydrogen chloride during the treatment with chlorsulphonic acid indicated that the principal reaction was the sulphonation of aromatics,[11] probably together with the sulphonation of the more reactive tertiary hydrocarbons.[12, 13] This is supported by the smaller recovery of oil (37 per cent) after one treatment with chlorsulphonic acid than after four washes with concentrated sulphuric acid (50 per cent). Only a small proportion (1 per cent) of sulphonyl chlorides was formed, probably by the action of the excess chlorsulphonic acid on the sulphonic acids formed.[14, 15]

The treatment with urea [1-4] confirmed the suggestions made by earlier workers [*e.g.*, 16] that there was a large proportion of straight-chain hydrocarbons present in shale oil. The approximate composition of the gas oil, given in Table V, based on the results of this method of analysis, coupled

TABLE V

Composition of Gas Oil as Shown by Urea Fractionation

Urea adduct	Percentage by weight		By volume	
Normal paraffins	14·7		17·4	
Normal olefins (by difference)	12·3	27·0	14·5	31·9
Residue from urea :				
Naphthenes and *iso*paraffins	23·4		22·9	
iso- and *cyclo*-Olefins (calc) [(a)]	26·2		25·6 [(b)]	
Aromatics (by diff)	23·7	73·3	21·1	69·6
Total		100·3		101·5

(*a*) The olefin content was assumed to be proportional to the bromine number (Table IV) and was calculated to the same basis for the urea residue as for the *n*-paraffin *n*-olefin fraction.

(*b*) Sp. gr. assumed 0·87 same as for naphthene–*iso*-paraffin fraction.

with the use of concentrated sulphuric acid to remove olefins and aromatics from the fractions. The higher specific gravity of the saturated fraction of the oil remaining after treatment with urea indicates the presence of an appreciable proportion of naphthenes. Attempts to use thiourea to isolate

the *iso*paraffin–naphthene–*iso*-olefin fraction directly [17, 18] gave variable results which could not be duplicated, and which were therefore in agreement with the unstable character of these complexes.[18]

Acknowledgments

The authors wish to acknowledge with thanks the permission granted by the Management of National Oil Pty. Ltd., to publish this paper.

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ADDITION OF HYDROGEN SULPHIDE TO *ISO*-PENTENE WITH ALUMINIUM CHLORIDE AS CATALYST

By A. J. van Riemsdijk, J. van Steenis, and H. I. Waterman (Hon. Fellow)

Summary

According to Markovnikov's rule H_2S is added to 2-methylbutene-2 under the influence of aluminium chloride. The *tert*-amyl mercaptan formed is again added to the olefin, forming di-*tert*-amyl thioether.

The experiments have been carried out intermittently as well as continuously. Aluminium chloride compounds with mercaptan and/or thioether are more suitable catalysts for this addition reaction than pure aluminium chloride.

Under the reaction conditions, *tert*-amyl mercaptan and *tert*-amylthioether can be converted into each other.

Although the addition of H_2S to olefins under the influence of various catalysts has been described,[1] the use of Friedel–Crafts catalysts has been mentioned only in some recent patents.[2]

The present article surveys the addition of hydrogen sulphide to olefins under the influence of aluminium chloride or solutions of aluminium chloride in mercaptan and/or thioether. This investigation was carried out in particular with 2-methylbutene-2, while provisional results were obtained with propene, *iso*butene, *n*-pentene-1 : 3-methylbutene-1, 2-methylbutene-1, and *cyclo*hexene.

The 2-methylbutene-2 was prepared from *iso*amyl alcohol by dehydration with aluminium oxide at 400° C, followed by rectification of the reaction product in a column with about 25 theoretical plates.

Use was made of the fraction boiling between 36° and 38° C and consisting mainly of 2-methylbutene-2, with possible contamination by 2-methylbutene-1.

Experimental

In a tube of about 3 cm diameter and 20 cm length, $AlCl_3$ is mixed with approximately the same volume of tertiary amyl mercaptan and/or di-*tert*-amylthioether, so that a liquid mixture is formed. Hydrogen sulphide (prepared from FeS and diluted HCl; traces of hydrochloric acid in the gas are removed by means of FeS and moisture with aqueous calcium chloride) is next fed to the bottom of the tube while stirring the liquid vigorously. The olefin is slowly added from a dropping funnel at the top of the tube. After the total quantity of olefin has been added the hydrogen sulphide stream is continued till gas is no longer absorbed. This is checked by measuring the gas flow before and after the reaction vessel. The temperature is kept constant during the reaction.

The reaction mixture consists of two layers, a catalyst compound and a clear top layer. The latter is separated, washed with water, and dried

with anhydrous Na_2SO_4, followed by a rectification in a column with an electrically heated jacket and about 10 theoretical plates.

The typical distillation curve of the reaction product is shown in Fig. 1, which indicates that two fractions have mainly been formed.

The lowest-boiling fraction has a boiling point of about 99° C, and is soluble in diluted sodium hydroxide solution.

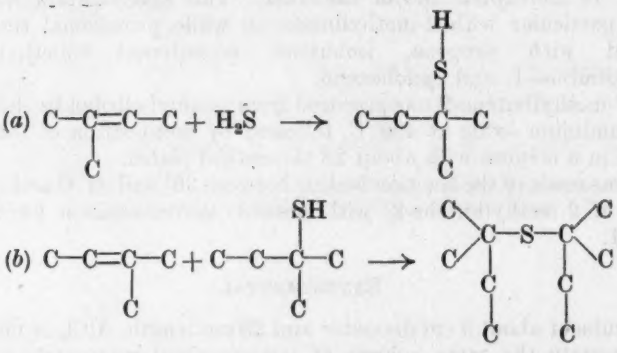
Treatment of this fraction with mercuric cyanide in an acetone solution yields a mercury compound melting at 61° C.

According to the literature the melting point of the mercury salt of *tert*-amyl mercaptan is 60·5° to 64° C.[3, 4] For *tert*-amyl mercaptan an n_D^{20} of 1·4379 [3] and a boiling point varying from 98° to 100° C [3] are given in the literature. The values found in this work were 1·4376 and about 99° C, so that it may be concluded that this fraction consists of *tert*-amyl mercaptan.

The fraction with the highest boiling point (about 199° C) has an n_D^{20} of 1·4672 and a density (d_4^{20}) of 0·8554. The sulphur content is 18·8 per cent. This value corresponds with the sulphur content of a diamylthioether (18·4 per cent).

No values could be found in the literature for the di-*tert*-amylthioether. Since the catalyst used will promote addition according to Markovnikov's rule, while as is shown below, treatment of the 199° b.p. fraction with H_2S and aluminium chloride gives rise to the formation of *tert*-amyl mercaptan, it is very probable that the high-boiling fraction found by us consists of di-*tert*-amylthioether.

The following reactions may have taken place :—



Considering these results, the above-mentioned possible contaminations of the raw material will not influence the reaction products, since addition of H_2S according to Markovnikov may be expected to lead to the same mercaptans and thioethers both with 2-methylbutene-2 and 2-methylbutene-1.

By starting from the fraction with a boiling point of 30° to 33° C, mainly 2-methylbutene-1, obtained from the reaction product of the dehydrogenation of amyl alcohol, the reaction products described were actually obtained.

The yield of sulphur compound in the reaction described above is about

70 per cent of the olefin added. It was therefore expected that the continuous process would yield satisfactory results, and the apparatus used for this is shown in Fig. 2.

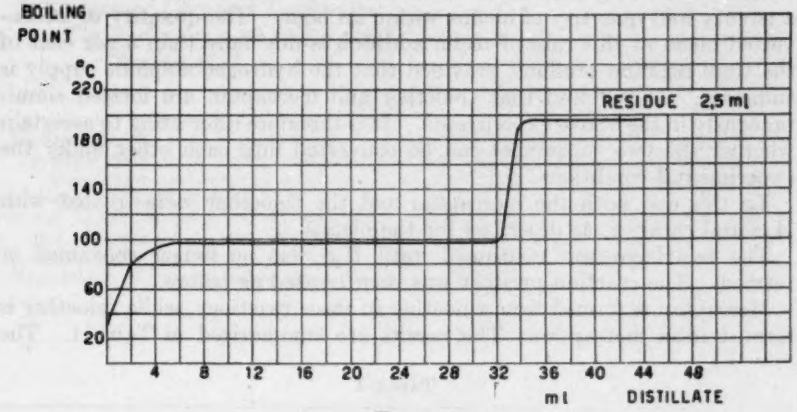


FIG. 1

RECTIFICATION OF THE REACTION PRODUCT OF 2-METHYLBUTENE-2 AND H_2S

From the reaction vessel *A* (capacity about 50 cc) the reaction mixture passes to B, where it is separated into a (heavy) catalyst layer, which is returned to the reaction vessel via *C*, and a top layer, containing sulphur compounds and unconverted olefins. From *C'* this top layer is taken to

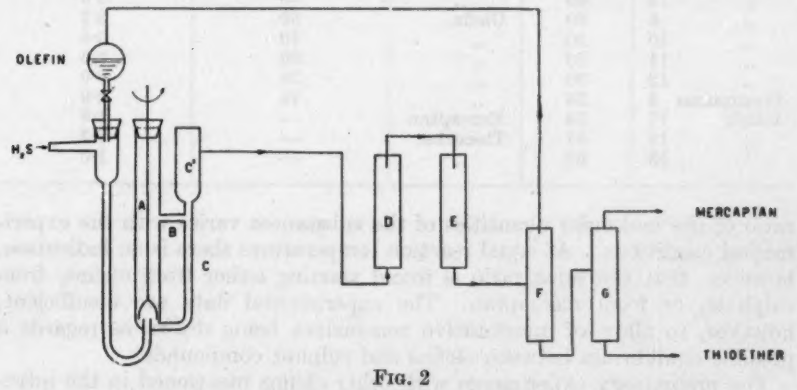


FIG. 2

DIAGRAM OF CONTINUOUS ADDITION OF H_2S TO 2-METHYLBUTENE-2

D, where it is washed with water to remove the last traces of catalyst. At first the reaction product was dried with aqueous Na_2SO_4 in *E*, but on account of clogging difficulties it was decided to change to direct rectification in columns *F* and *G*.

Unconverted olefin is recovered in *F*, the mercaptan collected at the top of *G*, while the thioether fraction is obtained at the bottom of *G*. An

analysis of the fractions showed that the first (mercaptan) fraction contained about 90 per cent mercaptan, and the other fraction about 70 per cent thioether.

With about 10 g aluminium chloride it is possible to convert more than a twenty-fold quantity of olefins within an hour. The quantity of unconverted olefin at this rate of olefin addition is not more than 5 per cent of the total reaction product, provided that the hydrogen sulphide supply is sufficient. It is found that thioether and mercaptan are formed simultaneously in the above experiments. It is therefore interesting to ascertain whether the two substances can be converted into each other under the experimental conditions.

To this end both the mercaptan and the thioether were treated with H_2S and catalyst, as described for the olefins.

The treatment was continued until H_2S was no longer consumed or formed. The reaction product was then treated as before.

Mercaptan is formed from thioether in these reactions, while thioether is formed from mercaptan. The results are summarized in Table I. The

TABLE I

Experiment no.	Reaction temp, ° C	Initial product	Olefins converted into mercaptan + thioether (approximately), per cent	Mol. mercaptan mol. thioether
Continuous 5	−20	Olefin	30	1·0
,, 4	0	,,	75	1·6
Batch 15	0	Thioether	—	1·5
,, 19	10	,,	—	2·6
,, 14	20	,,	—	3·6
,, 6	20	Olefin	50	3·3
,, 10	20	,,	70	3·8
,, 11	20	,,	90	5·5
,, 12	20	,,	70	2·9
Continuous 3	35	,,	70	2·9
Batch 17	53	Mercaptan	—	1·8
,, 18	57	Thioether	—	1·3
,, 13	62	,,	—	1·0

ratio of the molecular quantities of the substances varies with the experimental conditions. At equal reaction temperatures there is an indication, however, that the same ratio is found starting either from olefins, from sulphide, or from mercaptan. The experimental data are insufficient, however, to allow of quantitative conclusions being drawn as regards a possible equilibrium between olefins and sulphur compounds.

The preliminary experiments with other olefins mentioned in the introduction yielded analogous results as regards the formation of mercaptan and of thioether. The yield is small for the examined primary and secondary olefins, while tertiary olefins prove to react very readily.

In some cases, particularly at higher reaction temperatures (40° C and higher), some polymer formation is observed during the reaction with *iso*pentene. If the reaction is started with pure $AlCl_3$ instead of with the catalyst complex of mercaptan or thioether with $AlCl_3$, the polymer formation is stronger at a short test duration. When a quantity of sulphur

compounds is present sufficient to form the catalyst complex, the results are analogous to those of experiments started directly from the complex.

Laboratory of Chemical Technology,
The Technical University, Delft.
August 1950.

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CORRESPONDENCE

" The Preparation of Specimens of Bitumen, etc., for the Penetration Test."

To the Editor, *Journal of the Institute of Petroleum.*

SIR,

We have used for some considerable time a method for the preparation of specimens for the penetration test of bitumens, etc., which we think will commend itself, particularly in these times of difficulty in obtaining the containers appropriate for holding the material under test. It has the further valuable advantage of offering a trouble-free surface to receive the needle.

Briefly, it consists of filling with the bitumen a metal ring of the required internal dimensions, supported upon a level sheet of brass or other suitable metal, which has been previously treated with mercury to amalgamate the surface. The face of the bitumen adjacent to the amalgamated surface is readily detached and provides a perfectly level, bubble-free face for test purposes.

For soft bitumens of high penetration, a metal disc can be placed over the rings when they are filled, and fixed by a slight overflow of the bitumen, to form a foundation when the specimens are removed from the treated base-plate.

If the rings and the base plate are sufficiently robust, they can be used indefinitely to affect a substantial saving of the tin containers ordinarily used.

Finally, if glass vessels are employed for the purpose of the test, instead of the copper holders which are frequently used, with the perfectly level surface of the test specimen prepared as described, the difficulty of determining when the point of the needle is exactly touching the bitumen surface can be eliminated.

T. ADAMSON.

Wailes Dove Bitumastic Ltd.,
Hebburn,
Co. Durham.
March 22, 1951.

OBITUARIES

ERNEST ARTHUR SATCHELL

Of the team of brilliant men which Mr Skliros, then general manager of the Iraq Petroleum Company, had the felicity to attract to the company, none was better known than Ernest Satchell. His death on April 11 deprives the British oil industry not only of one of its leading production engineers but also of one of its most vivid personalities, for all who knew him recognized " Ernie " Satchell as " a character."

Satchell was born in 1888, the son of a schoolmaster, and was educated at Alleyn's School, Dulwich. Soon after leaving school he went to America in 1907 to join an elder brother who had emigrated to California. There, he started work in the gauger's office of California Oilfields Ltd. at Coalinga, but, impatient of office life, insisted on being demoted to a " roustabout " on the Coalinga east field. There, his astute mind and keen observation enabled him to make such use of his opportunities that he caught the eye of T. O'Connell, who set him to work as a production man for Doheny interests in the Ventura field. Shortly after the outbreak of the first world war he enlisted at the British Consulate in Los Angeles and served in the Royal Engineers in East Africa. After the war he returned to California, but soon joined the Huasteca Petroleum Company in Mexico. Later, he was transferred to Venezuela, where he became general superintendent of the Lago Petroleum Corporation's operations at Maracaibo. Such was the school in which Satchel acquired the technical knowledge and economic acumen which he later applied with such conspicuous success to the problems of Iraq. He became a Member of the Institute in 1929, and at one time served on the Publications Committee.

He joined the Iraq Petroleum Company in 1930 when the scheme for the production of 4 million tons per annum from the Kirkuk field was being formulated. He brought with him experience of limestone production in the fabulous Golden Lane of Mexico, but, at that time, few men would have had the foresight or the courage to concentrate production on a 10-mile stretch of the 60-mile Kirkuk reservoir. From the very beginning the production system was devised by Satchell to make full use of reservoir characteristics, some of which were already established, but others were deduced with an instinct which has since proved unerring in its recognition of principles and forecast of performance in the years which then lay ahead. Taking advantage of the natural system of communication throughout the reservoir, the original scheme for a production of 90,000 barrels per day was from fourteen flowing wells covering a 10-mile stretch of the Baba dome, thus concentrating production facilities and reducing gathering systems to a minimum.

In the post-war years Satchell was responsible for the expansion of production to the present rate of 7½ million tons per annum, still from the Baba dome, and of planning the production of 20 million tons from the Kirkuk field. At the time of his death the installation of facilities for this

quantity was well advanced, and everything will be ready when the 30-inch line from Kirkuk to Banias comes into operation at the end of 1952.

Those who have been privileged to walk with him at night from the guest house at Kirkuk to the crest of Arrapha Ridge and, as the lights of the stabilization plant and the degassing stations came into view, to hear his "There it is young fellow," will think of them as a monument to Ernest Satchell. They will know, too, that he would wish no other, for in that achievement he had a satisfaction that was both deeper and more modest than pride.

In all his dealings with friends and colleagues sincerity was the keynote—you never had any doubt where you stood with E. A. Satchell—but of all his personal qualities two were outstanding: the courage, which was never more typified than in the fortitude with which he endured a long and painful illness, and the love of his home and family. In them he found an enduring peace and a source of that strength which sustained him to the end. In that knowledge, his friends will not complain that, in recent years at least, it was that deep love of his home which deprived them of his company at many oil-industry functions.

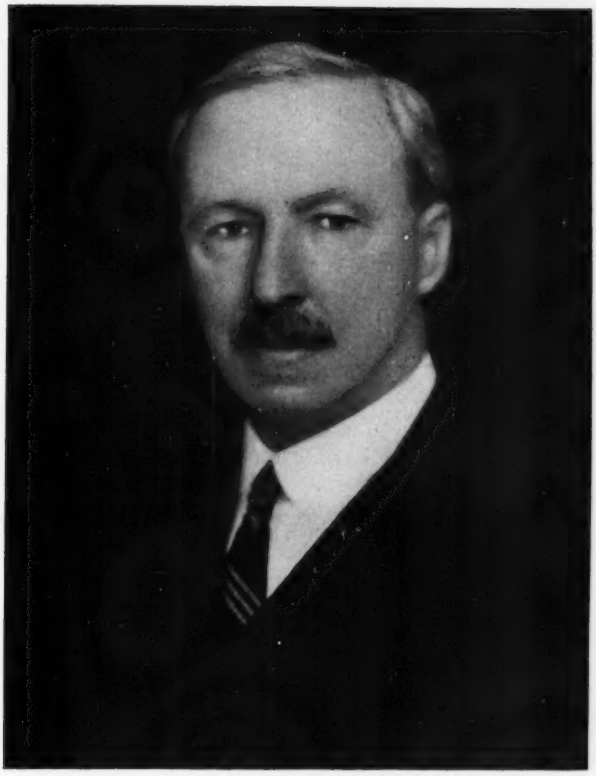
C. T. B.

JAMES KEWLEY

THE passing of James Kewley has removed from the Institute one of its most distinguished and faithful sons.

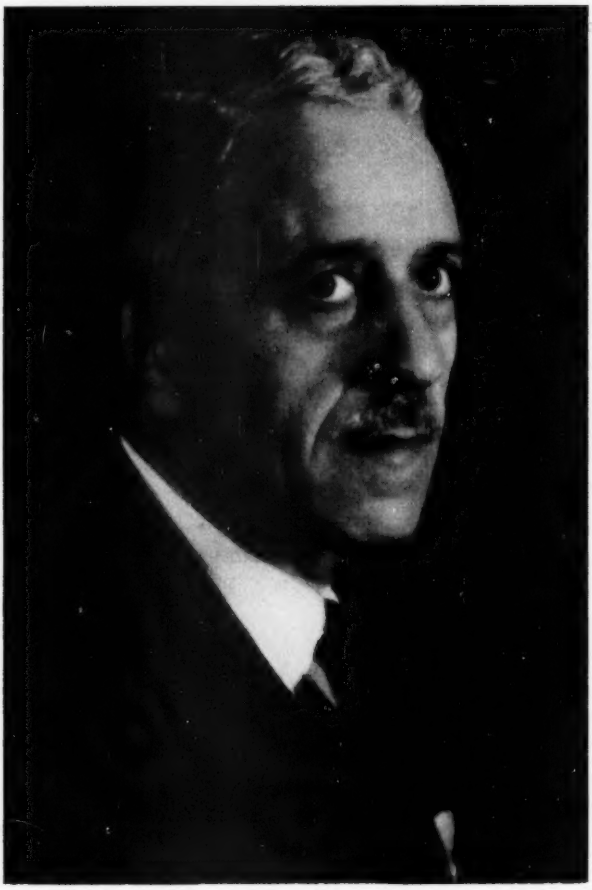
Those of us who were privileged to work alongside him in the early days of the Institution of Petroleum Technologists know full well how readily he spent himself in its service—they also know full well the innate kindliness of the man himself, his constant friendliness, and his willingness to sink his own personality for the common good. There are but a few of us left who can testify to those attributes. Many of his earlier colleagues have departed before him, but I need only mention the names of some of his older friends who now lament him: J. S. S. Brame, T. Dewhurst, S. J. M. Auld, F. B. Thole, and J. S. Jackson amongst others. True it is that he belonged to the generation of Cadman, Greenway, Adams, and Barringer, but he had the capacity of youthfulness and could fit in so admirably with the younger men who were controlling a growing and greater Institute.

For a sketch of his early days, I am indebted to the Principal of his old school, King William's College, Isle of Man. Kewley was a scholar of his college, and was outstanding in his devotion to science—apparently at that distant date he built a wireless transmitter and sent messages across the Island. In 1898 he won a scholarship at King's College, Cambridge, taking a First in Part I Natural Science Tripos in 1901 and a Second in Part II in the following year. He spent four years as science master at his old school, but in 1906 he joined the Shell Group and proceeded to Balik Papan in charge of the control laboratory there. After a visit to the U.S. to investigate the Trumble outfit, he was transferred to the Suez refinery. During the first world war his responsibility increased. He took charge of the installation at Portishead (where a rich toluol fraction was produced from Borneo benzine) and came to London in 1919 to become chief chemist of the Asiatic Petroleum Co. Mr Hyams has kindly put at my disposal much of this biographical detail.



JAMES KEWLEY
1879–1951

[*To face p.* 272.



ARTHUR WADE

1878–1951

Perhaps the greatest work he did, and one that will long live after him, is the training—and good, thorough training too—that he gave to a great host of chemists who passed through his hands—chemists distributed over the whole globe and full of love and affection for him who was very truly the " Father of his Flock."

Let us now praise famous men.

A. E. D.

ARTHUR WADE

WITH the sudden death while surf bathing on April 8 at Mermaid Beach, near Brisbane, Queensland, Australia, of Dr Arthur Wade, the petroleum industry loses another of its pioneers, and one of its most interesting personalities.

Born in Halifax, Yorkshire, in 1878, Arthur Wade took his B.Sc. with First Class Honours in Geology at London University, and in 1911 gained his degree of D.Sc. While at the Royal College of Science he was Murchison Medallist and Prizeman in 1904 and gained the King's Medal for Geology in 1905. In 1908 he gained his Associateship of the College and was for a time a member of the teaching staff. He remained in this position for some five years and combined it with consulting work in relation to petroleum. In the course of this work he visited Egypt, Cyprus, Turkey, Russia, Palestine, and Syria.

In 1913 Dr Wade became interested in the prospects of finding petroleum in Australia, a subject that was to be of absorbing interest to him for practically the whole of his subsequent career. It was in that year that he entered the service of the Commonwealth Government of Australia and carried out a lengthy reconnaissance for oil in Papua. In 1915 he became Director of Oilfields for the Government, and until 1919 spent much time in the field on the mainland of Australia.

In 1924 he returned to Australia to carry out further investigations into oil prospects and also represented the Commonwealth at the Conference of Australian Geologists in 1924–25. In 1933 he was again invited to go to Australia to examine the oil possibilities of the northern areas, and this work occupied him until 1936. He was then appointed to the Australian Commonwealth Oil Advisory Board, and was its chairman until its dissolution in 1940. He then became geological adviser to the Shell (Queensland) Development Co. and established his headquarters in Brisbane. In this sphere he was largely responsible for the location and supervision of geological work on the deep test well at Morella, and it was a bitter disappointment to him when this had to be abandoned.

In the Institute of Petroleum, which he joined in 1921 and of which he was a Fellow, Dr Wade was an indefatigable worker. He was first elected to the Council in 1930, and he remained a Member of the controlling body until his resignation in 1945. During the few years that he was destined to remain in England—1930–33—he was a regular attender at meetings, and served on the Benevolent Fund, Finance, House, Library, and Publications committees, and was appointed as Honorary Librarian a few months before he left for Australia in 1933.

Dr Wade was the author of various Parliamentary and Government

publications on petroleum investigations in Australasia, and in our own *Journal* has contributed on geology or oil prospects of the Ionian Islands, of Zante, of Coastal Asia, of Madagascar, of Hardstoft in Derbyshire, of Australia, and of Texas. During the second world war, in which he served on the staff of the Chief Engineer, G.H.Q., U.S. Army, S.W.P. area, 1943–44, and on Allied Intelligence. He was also the author of *The Borneo Book for Servicemen*, a book published by G.H.Q. Australia for the use of personnel engaged in the Far East.

He was an active man both in brain and in body, and preferred work in the field to a sedentary occupation. His favourite recreations were golf, tennis, swimming, and walking.

Arthur Wade will be remembered by many for his outstanding ability, his entertaining companionship, and his friendship. He was forthright and outspoken in his opinions and in his criticisms, and while this made him some political enemies, it endeared him the more to his friends and colleagues, who knew his steadfastness of purpose.

He married Mayme L. Souter of Missouri in 1924, who survives him with one daughter and a son. His many friends will join in expressing condolences to them in their loss.

In his spare moments, Arthur Wade was something of a poet, and his volume " Vagabond Verse " was published first in 1917 and had a third edition in 1947. We feel sure that he would like us to conclude with the opening lines of one of his works :

> *When, at the post, this mortal form I shed*
> *Let those who saw me pass remember me*
> *Just as I was.*

L. O.
G. S.

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Oilfield Exploration and Exploitation

Geology

1151. Appalachian region. Appalachian Geol. Soc. *Bull. Amer. Ass. Petrol. Geol.*, 1937, **35**, 438–57.—The oil and gas provinces of the Appalachian region considered in this paper are located in or adjacent to the Allegheny synclinorium which extends from Tennessee to central New York and is 700 miles in length. The eastern and southern boundary has been extended past the Appalachian structural front to the boundary of the basement complex. The area south of the Kentucky–Tennessee state line is not discussed.

The Appalachian region extending from the crest of the Cincinnati arch on the west to the boundary of the basement complex on the east is estimated to include 171,000 sq. miles, and all of this area is regarded as a possible petroliferous province. The max thickness of sedimentary rocks is probably about 35,000 ft. About 50% of the rock is shale and about 25% of the shale is carbonaceous. Dolomite, anhydrite, dolomitic limestone, and limestone comprise about 30% of the rock, and the remaining 20% is sandstone.

The entire region contains about 500,000 cu. miles of sedimentary rocks with 460,000 cu. miles above a depth of 20,000 ft and 40,000 cu. miles below that depth.

E. N. T.

1152. Palo Duro Basin warrants attention. P. C. Ingalls. *Oil Gas J.*, 12.10.50, **49** (23), 147.—There are good oil possibilities in the Permian, Pennsylvanian, and pre-Pennsylvanian beds in structural or wedge-out traps on the east side of the Palo Duro Basin in the Texas Panhandle area. There may also be oil-bearing Lower Permian or Upper Pennsylvanian reef uplifts within the Basin similar to those exploited in the Permian Basin.

To the north the Basin is bounded by the Amarillo Granite Ridge on which is the Panhandle field. To the south, dividing the Palo Duro Basin from the Permian Basin, is the Matador Arch, now believed to be a series of small separate structures.

C. A. F.

1153. Three critical environments of deposition, and criteria for recognition of rocks deposited in each of them. J. L. Rich. *Bull. Geol. Soc. Amer.*, Jan. 1951, **62** (1), 1–19.—Three depositional environments can be recognized in any body of standing water which is subject to wave action. These are the unda, clino, and fondo environments, and in each there are distinctive compositional and depositional features, from which the depositional environments can be determined.

In the undaform, which lies above wave base, sediments are coarse, fossiliferous, and discontinuous, with well-defined bedding which is commonly "wavy." The clinoform is the sloping surface lying between the undaform and fondoform, the floor of the water body. Clinoform rocks are fine-grained with thin and even bedding show evidence of gravity sliding. Fondoform rocks are also fine-grained, but there is no secondary sorting and the bedding is commonly massive.

These environments are shifted by changes in sea-level. If sea-level falls, sands are deposited along the outer shelf on the undaform, and these may become oil and gas reservoirs. Some of the supposed "shoreline trends" along the Gulf Coast and elsewhere may be sands of this type, which are more likely to be preserved than offshore sand bars.

Eleven photographs show the nature of the bedding in the three environments, and twenty-three references are included. C. A. F.

1154. Possible future petroleum provinces of North America. M. W. Ball. *Bull. Amer. Ass. Petrol. Geol.*, 1951, **35**, 141–4.—An introduction to the symposium presented at the 35th annual meeting of the American Association of Petroleum Geologists, held in Chicago during April 1950. M. W. Ball acted as chairman of the symposium committee and pointed out that in the nine years which have passed since the 1941 symposium, the outlook of petroleum geologists has been extended both geographically and geologically.

The 1941 volume, for example, contained no mention of the continental shelf and no suggestion of the importance of reefs; it gave little consideration to possibilities in deeper strata in geological basins already productive in upper beds; and it considered no possibilities deeper than 15,000 ft.

Papers in this symposium described below contained descriptions of nearly twice as many possible oil provinces as in the 1941 volume. However, certain of the 1941 limitations have been retained:—

1. As in 1941, areas known to have a sedimentary section of less than 1000 ft are not considered.
2. The lower limit of sediments for the computation of sedimentary volume has been increased from the 15,000 ft of 1941 to 20,000 ft, but where possible the sedimentary volume below 20,000 ft has been separately computed and given.
3. In 1941 unexplored areas within present oil and gas provinces were not included. For reasons already given, this rule has been modified; present provinces have been included if their deeper possibilities or possible important extensions have not been adequately explored.
4. The 1941 symposium omitted areas in which the information was too meagre to warrant venturing an opinion on oil and gas possibilities. This limitation has been kept, but some of the areas omitted in 1941 have now been included because of additional information.

The papers presented represent the work of seventeen geological societies, thirteen federal, state, and provincial geological surveys or analogous organizations, representatives of thirty-three or more oil companies and eight universities, and twenty-four consulting geologists. E. N. T.

1155. Northeastern United States. J. L. Anderson. *Bull. Amer. Ass. Petrol. Geol.*, 1951, **35**, 421–37.—The area comprising the possible oil provinces of the northeastern part of the United States as described in this paper extends from the northern boundary of North Carolina at 36° 30′ north latitude to 42° north latitude. The western boundary of the province is the Fall Line, where the younger sediments lap up against the igneous and metamorphic rocks of the Piedmont and New England physiographic provinces. The strike of the Fall Line in southern Virginia is almost north, but gradually changes to northeast near the Virginia–Maryland boundary. The Fall Line passes in an almost eastward direction through the northern part of Long Island, New York. From east to west, the province extends from about 66° West Longitude to 77° 20′ at the southern boundary of Virginia.

The area includes parts of the states of New York, New Jersey, Delaware, Maryland, and Virginia. It consists of two parts, the one known as the coastal plain extending

from the Fall Line to the present coast-line of the Atlantic Ocean, the other, the continental shelf, extending from the coast-line to the outer edge of the shelf.

The states considered in detail are New Jersey, Maryland and Delaware, Virginia, and New England. E. N. T.

1156. Southeastern United States. Various Authors. *Bull. Amer. Ass. Petrol. Geol.*, 1951, **355**, 399–420.—The oil possibilities are considered of one of the less-favourable regions of the United States, although it must be admitted that Mississippi is a proved oil province. The states considered in detail are Mississippi, Alabama, Florida, Georgia, North and South Carolina, and Tennessee. E. N. T.

1157. Regional study reveals Colorado oil prospects. C. F. Barb. *World Oil*, Feb. 1951, **132** (2), 72.—Oil in Colorado is produced from formations ranging from Tertiary to Permian, but most fields produce from the Lower Cretaceous. Several tests have been drilled to basement in the east and west of the state, and oil indications have been found in pre-Permian beds, though not in commercial quantities, except in the Rangely field.

Between Wyoming and New Mexico the Dakota sandstone, a major producer in a number of fields, outcrops against the Front Range. Dakota production in this general area is unlikely, since the formation is flushed by surface waters; beds below the water-bearing Dakota may be oil-bearing where there is a favourable structure. In the Plains area most wells have been abandoned in the Dakota, and zones beneath have been insufficiently tested.

In the western part of the state, structures are stronger and thrusting is common. The Dakota may be productive in this area in fault traps or strong closures.

A table showing geological sections and correlations in Colorado is included.

C. A. F.

1158. Midcontinent region. Tulsa Geol. Soc. *Bull. Amer. Ass. Petrol. Geol.*, 1951, **35**, 316–43.—The outstanding structural feature of the Dakotas is the Williston basin. It is bounded on the east and southeast by gentle, rather featureless dips off the Canadian shield and the Sioux uplift, and on the west by the abrupt Black Hills uplift and the lesser Baker-Glendive anticline of eastern Montana. More pronounced local structures are present in South Dakota, but the chief present interest in the petroleum possibilities of North Dakota is related to the regional structure.

The combined area of the two states is approx 100,000 sq. miles. The thickness of sedimentary rocks ranges from 1000 to 12,000 ft or more. The average thickness is about 6000 ft, and the sedimentary volume is about 115,000 cu. miles. Subsurface structural information is available from seventy-nine wells, and thirty-two wells have been drilled into pre-Cretaceous beds. Not more than half of these wells were actual tests for oil and gas. The deepest test is the California's Company's Kamp No. 1, drilled to 10,281 ft in Williams County, North Dakota. It stopped in either Ordovician or Devonian limestone.

Much of the surface is mantled by glacial till and unconsolidated late Tertiary sediments, which are a handicap to geophysical exploration.

Showings of oil and gas are rather meagre, but certainly not enough wells have been drilled to condemn the area. In North Dakota wells, showings have been reported in the Benton, Dakota group, Mississippian, and Ordovician. In South Dakota, similar showings are reported in the Dakota group, Jurassic, Pennsylvanian, Mississippian, and Ordovician. The progressive overlap of Mesozoic formations deposited over the apparently truncated Paleozoic formations places a series of favourable wedges along a north–south belt just east of Bismarck. An opinion that the sediments of the Dakotas lack sufficient porosity may well be premature because of the small number of deep tests. Favourable local structures may be found in the deeper parts of the basin or on its flanks.

The areas examined in detail are as follows: Western Nebraska; Salina and Forest City basins, Kansas, Nebraska, Missouri, and Iowa; Salina basin; Forest City basin; Southeastern Oklahoma–Northwestern Arkansas; and the Anadarko basin.

E. N. T.

1159. Eastern Interior basin. Illinois Geol. Soc. *et al. Bull. Amer. Ass. Petrol. Geol.*, 1951, **35**, 486–98.—The Eastern Interior basin, in Illinois, Indiana, and Ken-

tucky, has produced oil for more than sixty years and has been a major producing province for forty-five years. During this time nearly 1¾ (U.S.) billion brl of oil have been obtained from the basin. Its reserve producible by current methods is about ¾ billion brl, and the use of water flooding and other secondary methods may add another ¼ or ½ billion brl to the recoverable reserve. About three-quarters of the current annual withdrawal of 80 million brl of oil is being replaced by new drilling, largely in extensions to known pools.

The most promising part of the Eastern Interior basin for future discoveries in the Devonian and Silurian formations is the 2400 cu. miles of sedimentary rocks under a rather broad belt of 17,000 sq. miles across the north-central part of the basin that is nearly bisected by the La Salle anticline. Three areas, in which there are producing fields within this belt, total about 6000 sq. miles and 900 cu. miles. The thickness of Devonian and Silurian ranges from less than 500 ft near the northern margin of this crescentic belt to a little more than 1000 ft at some points along the southern margin.

E. N. T.

1160. Pacific Coast states and Nevada. Pacific Section of A.A.P.G. *Bull. Amer. Ass. Petrol. Geol.*, 1951, **35**, 185–273.—Experience influenced the A.A.P.G. Pacific Coast committee in its decision to examine critically and report on the future petroleum possibilities not only of the most promising undeveloped and producing regions but also of those regions that seem to offer little encouragement for further exploration. Only eastern Washington, the Modoc Lava Plateau in northeast California, and a part of the Northern Coast Ranges of California are insufficiently interesting to merit consideration. The predominance of igneous and metamorphic rock exposures in these regions seems to eliminate them, at least for the present, from favourable consideration as possible future oil provinces.

The continental shelf adjacent to Southern California is treated in some detail, but the rest of the Pacific Coast continental shelf is not discussed in separate papers. The future oil possibilities of any part of the continental shelf may be considered as similar to the possibilities of the contiguous land area.

Detailed papers are included on the following areas by the authors named: Washington, by T. J. Etherington; Oregon, by H. J. Buddenhagen; California, by G. C. Gester; Sacramento valley, by H. D. Hobson; San Joaquin valley, by J. E. Kilkenny; Central Coast Ranges, by J. E. Kilkenny and A. S. Huey; Santa Maria Province, by H. D. Dobson and B. C. Lupton; Ventura basin, by W. W. Rand; Los Angeles region, by Everett C. Edwards; Continental shelf–Southern California, by K. O. Emery; Southern coastal region, by Gordon B. Oakeshott; southern mountain region, by Gordon B. Oakeshott; Imperial valley, by Loyal A. Tarbet; Eastern desert and Mountain region, by W. H. Easton; and Nevada, by R. G. Ten Eyck.

E. N. T.

1161. Rocky Mountain region. Rocky Mountain Assn. of Geol. *et al.* *Bull. Amer. Ass. Petrol. Geol.*, 1951, **35**, 274–315.—The Rocky Mountain region—which includes seven states in the mountain and basin provinces of the Rocky Mountain system, the western part of the Great Plains Province north of central New Mexico, the Colorado Plateau, the eastern part of the Basin-and-Range Province, and the eastern part of the Columbia Plateau—has produced oil from strata ranging in age from Cambrian to Oligocene; almost all the oil and gas fields are on anticlines and domes with surface structural closures ranging from 90 to 3500 ft; lenticular sands on monoclines are yielding increasing amounts of oil; and minor amounts of oil are found in plunging anticlines and structural noses. The lowest altitude in an oil or gas field is about 2167 ft in the Bowdoin gas field, Montana, and the highest is about 8000 ft in the Wilson Creek, McCallum and Gramp's (Price) oilfields, Colorado.

The four groups of geologists named as authors have examined the structure of this vast area in great detail in a series of special sections.

They point out that the last pre-Cambrian disturbances in the Grand Canyon area are the oldest clearly differentiated in the region. Epeirogenic and local orogenic episodes during the Paleozoic and Mesozoic culminated in the late Cretaceous and early Tertiary Laramide orogenies, which caused almost all the observable folding in the region, some of the Laramide folds being renewals of late Paleozoic folds.

The present dissected Rocky Mountains are largely the result of several post-Laramide epeirogenic movements in the Tertiary and Quaternary, separated by

periods of erosion, the high altitudes of some ranges being caused largely by renewed movements along faults and by regional arching. Block faulting that began in the late Tertiary along the western border of the region has continued intermittently to the present.

The areas dealt with are: Central Montana; Powder River basin, Wyoming and Montana; Big Horn basin, Wyoming; Wind River and Jackson Hole basins, Wyoming; Green River basin, Wyoming and Colorado; Overthrust Belt, Wyoming, Idaho, and Utah; Great basin, Utah and Idaho; Four Corners Region, Arizona, Colorado, New Mexico, and Utah; Rio Grande basins, New Mexico and Colorado; and Eastern Colorado. E. N. T.

1162. Continental shelf of Gulf of Mexico. P. Weaver. *Bull. Amer. Ass. Petrol. Geol.*, 1951, **35**, 393–8.—Obviously, with so few wells drilled within the continental shelf of the Gulf of Mexico, it is difficult to present any detailed data from drilling within it. There are, however, some extrapolations from the results of drilling on adjacent land areas, with their geophysical surveys, and from a very limited amount of available geophysical mapping within the continental shelf area which are significant.

The Gulf of Mexico is constricted on the east by two peninsulas—the Florida and the Yucatan. Between these two peninsulas, the Gulf is bounded by a roughly circular coast-line. On land adjacent to this coast, the regional strike of the shallower formations is generally parallel with the coast, and the formations dip towards the coast, the shallow formations very gently, and the deeper formations somewhat more steeply.

Whether offshore the strike pattern continues to parallel the coast, and the dip rate continues offshore at the same rate as on land, is not agreed by various students. E. N. T.

1163. Western Gulf Coast. Houston Geol. Soc. *Bull. Amer. Ass. Petrol. Geol.*, 1951, **35**, 385–92.—Since the Gulf Coast Tertiary of Louisiana and Texas occupies the major position in production and reserves of the entire United States, its inclusion with possible future oil provinces may seem strange. Present production and known reserves are situated, however, almost entirely at depths less than 10,000 ft. This survey includes the sedimentary column to a depth of 20,000 ft.

Several fields are producing oil below 10,000 ft in formations where the actual top of the producing formation is much less than 10,000 ft, but the estimates of volumes of sediments for this province are for areas where the top of each formation considered to be in the future oil province is recorded at depths of 10,000 ft or more.

Underlying the area at present productive in Texas are two zones: one, 5000 ft thick on the average, between 10,000 and 15,000 ft in depth, which must be classed as possible; and a second, between 15,000 and 20,000 ft in depth, which is so speculative that it cannot now be considered a possible oil province. It is so remote, both laterally and vertically, from present stratigraphic control points, that only a suggestion can be made that it might be a part of the future oil provinces of the Gulf Coast.

More information is available regarding the subsurface Tertiary formations of Louisiana. Wells have been drilled below 10,000 ft in such numbers that the section is well known and the data are adequate to estimate the petroleum possibilities generally to 15,000 ft, and locally even to greater depths, and sufficient production is developed below 10,000 ft to place the rocks from that depth to 15,000 ft in the producing, rather than possible, status. However, changes in facies have been revealed in some of the Tertiary formations as they have been drilled to greater depths, and these changes, particularly for the older Tertiary, make an evaluation very hazardous in the section between 15,000 and 20,000 ft, excepting in the lower delta of the Mississippi River.

For these reasons this discussion of the possible future oil provinces of the deeper Tertiary rocks of Louisiana and Texas is limited to the part of the stratigraphic section that underlies present oil-producing areas in the Gulf Coast of Texas at depths between 10,000 and 15,000 ft. E. N. T.

1164. Fort Worth basin and Muenster arch, north-central Texas. Fort Worth Geol. Soc. *Bull. Amer. Ass. Petrol. Geol.*, 1951, **35**, 353–6.—Area described covers about 9400 sq. miles, of which 90 sq. miles are now productive of oil and gas, in more than fifty oil and gas fields. Sedimentary rocks range in thickness from about 100 ft on the

Muenster arch to 17,000 ft in the deepest part of the Forth Worth basin, with a total volume of about 17,000 cu. miles of sedimentary material. Producing depths range from the min of 500 ft to the max of 8900 ft in Cooke County. The deepest test well is the Denver Producing and Refining Company's Rich No. 1, Grayson County, which was drilled to the total depth of 13,352 ft, stopping in Ellenburger limestone. More than 6835 wells have been drilled in the area. The Fort Worth basin is a regional syncline approx 150 miles in length, varying in width from a few miles to 70 miles, and trending northwest.

The Muenster arch and the north end of the Fort Worth basin have been fairly well prospected, although without doubt many fields will still be discovered in this part of the area. The south part of the Fort Worth basin is relatively untested, and should have possibilities for new pools of both structural and stratigraphic type. E. N. T.

1165. Six countries report discovery prospects. Anon. *Oil Gas J.*, 12.10.50, **49** (23), 148.—1 Matthews Unit, Throckmorton County, Texas, after acidizing flowed 154 b.d. of 43° oil on test. The Mississippian limestone was topped at 4403 ft.

2 T. Bryan, Stonewall County, Texas, flowed oil and gas from the Swastika from 3658 to 3665 ft.

1 Hardison, Baylor County, on test flowed 200 brl of 41° oil in 3 hr from the Ellenburger at 5302 to 5314 ft.

New Bend production was found at 1 Zeldin in West County, Texas; on test the well gave a gas flow of 1 million cu. ft/day with 180 ft of oil in 90 min.

2 W. E. Bailey, Archer County, was completed for a production of 53 brl of 40° oil in 6 hr from Strawn at 3356 to 3369 ft. 2 B. Yates in Jack County also had Strawn production. C. A. F.

1166. Rank wildcat test opens new area. Anon. *Oil Gas J.*, 5.10.50, **49** (22), 291.—1 Pearl Wooten, 2½ miles east of Columbus, Colorado County, Texas, flowed approx 50 b.d. of 52° condensate from 8512 to 8540 ft.

1 R. W. Sharp *et al.*, Brazoria County, Texas, flowed 102 b.d. of 41·5° oil from 7609 to 7611 ft. Yegua production was found by 1 A. J. House, De Witt County, Texas, which flowed gas and condensate from 5336 to 5346 ft.

1 M. A. Hubbard, Calhoun County, Texas, flowed 12,500,000 cu. ft. gas/day from 8683 to 8686 ft. C. A. F.

1167. Downdip Mesozoic rocks of South Texas. South Texas Geol. Soc. *Bull. Amer. Ass. Petrol. Geol.*, 1951, **35**, 357–60.—The Downdip Cretaceous Province includes approx 16,500 sq. miles, located downdip from the Luling fault zone, underlying the Wilcox to Claiborne outcrop, and extending southwest from the Brazos River to approx the western boundaries of Zavala and Dimmit counties.

Regionally, the structure is a southwestward dipping homocline interrupted by local faulting or folding.

The rocks of Cretaceous age range in thickness from 4000 to 15,000 ft and have an average thickness of approx 7500 ft.

The deepest production is from the Lower Cretaceous (Edwards) at 9019 ft, and the shallowest is from the Upper Cretaceous (Navarro) at 425 ft.

Showings of oil and gas have been encountered in wildcat wells in all formations of the Cretaceous. The Navarro–Taylor sands (Upper Cretaceous) and the Edwards limestone (Lower Cretaceous) produce oil most prolifically in adjacent areas.

E. N. T.

1168. Plainview basin, Texas and New Mexico. T. S. Jones. *Bull. Amer. Ass. Petrol. Geol.*, 1951, **35**, 344–6.—The area of the Plainview basin is about 32,000 sq. miles. It is located between the outcrops of pre-Cambrian rocks in northeast New Mexico on the west, the Bravo dome and Amarillo uplift on the north, and the Matador trend of uplifts on the south. The belt of uplifts along the southern boundary of the basin is a westward continuation of the Red River uplift and the Electra arch, and may extend westward in New Mexico to include the Tertiary dikes and Capitan Mountains. It is named the Plainview basin after the largest town near the centre of the basin, but it has also been called the Palo Duro or Tulia basin, and seems to be a westward extension of the Hardeman syncline. The average thickness of sedimentary rocks is

about 8000 ft, the max thickness is about 11,000 ft, and their total volume is about 48,000 cu. miles.

Permian rocks cover the whole area, and constitute more than half the total volume of sediments.

Of the pre-Permian sedimentary rocks, the Pennsylvanian formations seem to be most favourable for the occurrence of oil.

The Mississippian limestone has not been a prolific producer in the province at the south, but is oil-stained in many places. In the Plainview basin it appears to be somewhat purer, and in places contains dolomite which has been mistaken for the Ellenburger limestone. Granite wash has filled the lowest spots in the pre-Mississippian surface.

The section of Ellenburger dolomite is thin at the east end of the basin. Elsewhere the older Paleozoic rocks have not been found north of the arch. Patches of Devonian, Silurian, and Ellenburger dolomite may eventually be discovered there and may contain oil. Identification of the age of such fragments would be difficult.

E. N. T.

1169. Western Canada. Alberta Soc. of Petrol. Geol. *Bull. Amer. Ass. Petrol. Geol.*, 1951, **35**, 169–84.—Events which have occurred in Western Canada since 1941 have changed the oil picture in that province.

Paper describes the developments which have taken place and the fresh approach to Western Canadian geological problems which have resulted from the extensive drilling programme.

The vast region termed the Western Canada sedimentary basin includes the foothills and plains, structural provinces, and certain outlying mountain ranges, but is generally defined on the west by the front range of the Rocky Mountains and on the east by the pre-Cambrian shield. This great belt has a width of 800 miles at the International Boundary, narrowing northward, and is 1600 miles in length from the International Boundary to the Arctic Ocean at the Alaska boundary. Eliminating the area underlain by sediments less than 1000 ft thick, along its eastern margin, the basin has an area of approx 600,000 sq. miles. The sediments overlying the pre-Cambrian basement rocks gradually increase in thickness westward from the thin eastern edge towards the mountains where the Cordilleran geosyncline was located. A max thickness of 25,000 ft of sediments is believed to underlie parts of the foot-hills belt. The gross volume of these sediments is estimated at 747,000 cu. miles, of which only 4000 cu. miles, located in the foot-hills of northeastern British Columbia, lie below 20,000 ft in depth. Within this region as a whole the sedimentary record is fairly complete from earliest Paleozoic through the Mesozoic and Cenozoic, although important gaps occur.

From west to east in the southernmost part of the Western Canada sedimentary basin the following structural units occur: (1) Front Ranges of Rocky Mountains; (2) foot-hills belt; (3) Alberta syncline; (4) Sweetgrass (or Bow Island) arch; (5) Moose Jaw (or Regina) syncline; (6) Alberta homocline; (7) Pre-Cambrian shield.

In Alberta the relatively few deep holes that have penetrated the pre-Devonian Paleozoic formations lend only slight hope for future production from these older strata. However, showings of oil or gas, or both, have been encountered in Cambrian beds in wildcat wells at three widely separated localities. Very little is known of Silurian, Ordovician, and Cambrian potentialities in Saskatchewan, northeastern British Columbia, and the Northwest Territories. The great developments of the last three years, related chiefly to Upper Devonian reef structures, have been widely publicized.

Special attention is also given to the oil sands of northern Alberta, which constitute a separate and unique oil province. They have an area of 10,000 to 30,000 sq. miles, range from a few ft to 225 ft in thickness, have a probable volume of 35 to 100 cu. miles, an oil content ranging from 1 to 20% of oil by wt, and are estimated to contain at least 100 (U.S.) billion barrels of oil.

E. N. T.

1170. Eastern Canada. Hudson Bay and James Bay Region. Various Authors. *Bull. Amer. Ass. Petrol. Geol.*, 1951, **35**, 458–85.—Covers the whole of Eastern Canada in some detail and the geographical surface, geology, and possible oil production in the

following provinces are discussed: Hudson Bay and James Bay Region; Ontario Peninsula; Central Ontario; Quebec; Maritime Provinces of Canada. E. N. T.

1171. Alaska. G. Gryc, D. J. Miller, and T. G. Payne. *Bull. Amer. Ass. Petrol. Geol.*, 1951, **35**, 151–68.—As at the time of the previous A.A.P.G. symposium in 1941, the potential petroleum resources of Alaska still cannot be appraised. However, since that report and other general outlook statements, some further advance has been made in the several more favourable areas towards obtaining the basic facts necessary for a better appraisal of the petroleum possibilities.

The Arctic slope of northern Alaska is now under intensive investigation by the U.S. Navy. The south coast areas—Katalla–Yakataga along the eastern half of the coast of the Gulf of Alaska, and the Cook inlet and Alaska Peninsula on the west—have also been studied recently by geologists. In the large part of Alaska between the north and the south coast areas, essentially nothing has been done towards specific exploration for oil, but oil shales are known in the eastern Yukon Valley, and unverified oil shales and oil seepages have been reported at several widely scattered sites in various parts of this large segment of the Territory. Continental Shelf areas along the Arctic, the Bering Sea, and the Pacific coasts are contiguous to known seepage areas, or areas of potentially favourable formations, and likewise have a possibility of becoming future sources of oil.

The authors consider in detail the area of Northern Alaska, north of the Brooks Range, where oil seepages have been known for years, the Arctic Foot-hills and the Arctic Coastal Plain.

Since the 1941 symposium, the search for oil along the south coast of Alaska has been continued only by surface geological investigations. No geophysical surveys are known to have been made with exploration for oil as the objective. Recent field investigations of some of the more promising areas in southern Alaska provide the principal basis beyond the statements of 1941 for re-appraisal of the possible future oil provinces in southern Alaska. Oil companies resumed field investigations in southern Alaska after the war, but the results have not been made public.

Consideration is also given to the Gulf of Alaska Tertiary Province and the Alaska Peninsula–Cook Inlet Mesozoic province.

Interior Alaska, as here defined, has an area of approx 200,000 sq. miles, extends from the international boundary to the Bering Sea, and is bounded on the north by the Brooks Range and on the south by the Alaska Range. Very little geologic information has been obtained that bears directly on the possibility of commercially productive petroleum. Geologic work, except for local studies of mineral deposits, has been mostly of reconnaissance character, and large areas have not been covered even in this manner. Thus, with a few exceptions, structures and stratigraphic sections have not been investigated in detail.

Finally, some mention is made of the oil possibilities of the continental shelf of Alaska. E. N. T.

1172. Colombian Petroleum Co. well makes 650 bbl daily. Anon. *Oil Gas J.*, 12.10.50, **49** (23), 74.—2 North Sardinata, west of Petrolea, Colombia, on test produced 650 b.d. of 54° oil from 8280 to 8305 ft. Pay is Cretaceous Aguardiente, which is productive at Petrolea and in the Tibu field.

Production from Petrolea is declining, current production averaging 1000 to 1500 b.d. The deep zone in the Tibu field is producing 6000 to 7000 b.d. Nine wells in the Rio de Oro field which were shut in during the war are to be opened, and a new deep test is to be drilled. C. A. F.

1173. Mexico–Lower California. F. Mina. *Bull. Amer. Ass. Petrol. Geol.*, 1951, **35**, 382–4.—Lower California is an unknown and untested oil province; no deep wells have been drilled in search of oil, and oil potentiality is not predictable from available information.

Despite limited quantitative information, the geological evidence is definitely favourable in three distinctive areas: (1) the Sebastian Vizcaino embayment, (2) the Eugenia Abreojos Province, and (3) the Iray Purisima region.

No oil seepages have been found in the area that extends southward from 28° to 24° north latitude. However, the thickness and type of sediments encountered and the structure are attractive for oil possibilities. E. N. T.

1174. Mexico. M. Alvarez, Jr. *Bull. Amer. Ass. Petrol. Geol.*, 1951, **35**, 361–81.—Seven possible future oil provinces or extensions of present oil provinces are described: the Burgos basin, the San José de las Rusias region, the Veracruz embayment, the Tabasco re-entrant, and three regions in Lower California.

The Burgos basin (Rio Grande embayment) has been known as a gas province for years, but the first oilfield was not discovered until 1948. It must be borne in mind, however, that only 100 exploratory and development wells have been drilled in the basin.

The Tabasco re-entrant may be divided into five regions, corresponding with four major structural units. The first structural unit is the Isthmian saline basin and its Tabasco extension. The other regions are the Huimanguillo basin, the Jalpa massif, and the Macuspana–Campeche basin. The Isthmian saline basin is already an important producer of oil, but because very little has been published concerning it and because a summary of its conditions of sedimentation, unconformities, and tectonics gives a better understanding of the four other regions, it is discussed in some detail, and special mention is made of the continental shelf which lies in front of it.

E. N. T.

1175. Oil found on Argentine side of Tierra del Fuego. Anon. *Oil Gas J.*, 12.10.50, **49** (23), 74.—A well completed 20 km northeast of Rio Grande, Tierra del Fuego, produced approx 72 b.d. Exploration in the area by Argentine operators commenced in 1945, and gas was found in 1949.

In the Carrodon Seco area of Comodoro Rivadavia, a well has been completed for 21,200,000 cu. ft. gas/day, and in the Plaza Huincul field another gas producer has been completed for 350,000 cu. ft/day. C. A. F.

1176. Scheerhorn test a success. Anon. *Oil Gas J.*, 12.10.50, **49** (23), 74.—Scheerhorn 8, north of Georgsdorf, Western Germany, initially flowed approx 75 b.d. from 3380 to 3410 ft. Three rigs are now developing the Scheerhorn structure.

Core holes are being drilled in new concessions in Upper Bavaria and South Baden. C. A. F.

1177. Preliminary observations on Ramandag field based on subsurface data. I. Tasman. *M.T.A. (Bull. of the Mining Research and Exploration Inst. of Turkey)*, 1950 (40), 55–9.—The Ramandag field, 92 km east of Diyarbakir, Turkey, is the first oilfield to be discovered in that country. The structure of the field is an anticline of Middle Eocene Midyat limestone which is underlain by Eocene Gercus red beds and grey Kermav shales. Turonian limestone and, in places, red and green marls occur beneath the shales. In the upper section of the Kermav beds there are streaks of white sand which locally contain asphalt or oil.

There is at present insufficient data for oil-reserve estimation. C. A. F.

1178. Much geological and drilling work remains in search for oil in Pakistan. H. Crookshank. *Oil Gas J.*, 12.10.50, **49** (23), 108.—Oil exploration is in progress in six areas of Pakistan. These are: the Punjab and Northwest Frontier Provinces, Eastern and Western Baluchistan, Sind, the Indus Valley, and Eastern Bengal.

In the Punjab oil has been found near Khaur, Dhulian, and elsewhere. Post-war drilling has found thick oil at about 8000 ft at Joyamair, and in Eocene limestone fissures at Balkassar. There are a number of potential structures in the Potwar and along the margin of the Salt Range which await drilling.

In Eastern Baluchistan there was small production in the 1870s from shallow wells near seepages in the Bugti area. Further small fields may be found.

In western Baluchistan gas has been found in shallow wells, but there are folded Tertiary beds and mud volcanoes which indicate that this area might be oil bearing.

In Sind a test well at Lakhra has found gas in the Cretaceous but no oil. There is a thick Tertiary–Mesozoic section which is folded into favourable structures, but no oil has yet been found.

In the Indus Valley Eocene beds are overlain by alluvium. Recent seismic surveys in the area have found no favourable structures.

Gas and oil seepages are common in anticlinal structures in Eastern Bengal, where the Badarpur field yielded approx 2 million brl. Wells have been drilled near Masimpur. C. A. F.

Geophysics and Geochemical Prospecting

1179. Case history of Benton field, Bossier Parish, Louisiana. C. N. Valerius and S. Von Croy. *Geophysics*, Jan. 1951, **16** (1), 14–28.—The geophysical history of the discovery of the Benton field, Louisiana, is described in detail. A regional gravity survey carried out in 1943 along the eastern flank of the Sabine Uplift indicated the presence of a prominent minimum trend. Subsequent reflection surveys showed strong west and north dips in the Benton area, and later more detailed surveys delineated the Benton structure.

The field produces from the Jurassic Cotton Valley "D" and Bodcaw sands. Development wells confirmed the seismic map on the Cotton Valley. The structure is an elongated anticline, approx 7 miles by 2 miles. Drilling has shown 60 ft of closure, but total closure, as shown by seismic evidence, must exceed 100 ft.

The field was developed efficiently and economically, due to early unitization as a result of the accuracy of the seismic data. C. A. F.

1180. An improved electrode system for use in electric logging. G. V. Keller. *Producers' Monthly*, Aug. 1949, **13** (10), 12.—A new type of electrode, known as the shielded mono-electrode, is described. The complete electrode consists of three parts: two long and cylindrical electrodes are placed above and below a shorter cylindrical electrode, all three being maintained at the same potential. The current flowing from the centre electrode is constrained to flow in a horizontal pattern for some distance from the electrode by the current flowing from the shielding electrodes above and below. The current flowing from the centre electrode is the only one measured, and in this way the resistance of a cylinder of rock having approx the same vertical thickness as the centre electrode can be computed. This is particularly useful in cases where it is necessary to find the true resistivity of beds which are relatively thin.

The theories of this method and of the conventional (single-point) electrode method are compared, and mathematical equations are presented for each case. The theoretical advantages of this type of electrode are substantiated by experiments with a laboratory model.

Six references are appended. R. B. S.

1181. Electric logging applied to groundwater exploration. P. H. Jones and T. B. Buford. *Geophysics*, Jan. 1951, **16** (1), 115–39.—A method is described whereby the quality of water in granular aquifers can be determined from electric logs in boreholes. The conventional method of interpreting resistivity logs from apparent resistivity curves using Archie's formula is outlined, and a method for converting resistivity into hypothetical chemical analyses is described.

Curves have been prepared showing the relation between resistivity and dissolved-solids content of waters from important aquifers in Louisiana. It has been found that the dissolved-solids content increases down dip, corresponding to systematic changes in chemical composition. This probably holds for most extensive aquifers. Curves were plotted to show changes in ion-concentration with increasing dissolved-solids content.

Three examples of the method are given and eight references are appended. C. A. F.

Drilling

1182. The balanced rotary rig. C. H. Oberg. *World Oil*, July 1950, **131** (1), 109–21.—Substantially as presented at the Ninth Annual Convention of the A.A.O.D.C. (See Abs. Nos. 64, 424, 1950.) A. H.

1183. Use of tubing as drill pipe. W. F. Bates. *World Oil*, Aug. 1950, **131** (3), 105–12.—(See Abs. No. 1773, 1950.) A. H.

1184. Drilling practices in the Permian basin. B. R. Schabarum and F. Smith. *World Oil*, Sept. 1950, **131** (4), 111–14.—Drilling in the Permian Basin has recently reached an all-time high due to the continual high rate of exploration for and the development of the prolific reef areas. The demand has been for rigs in the range of 5000 to 8000 ft with engine capacity of approx 500 h.p. Drilling masts have been popular because of low tear-down time, it being estimated that as much as 60% of drilling costs are related to time. Some difficulty has been experienced in obtaining

straight holes, and so diamond drills are commonly used. Large-dia collars and other special tools have been used to assist with this problem. Automatic feed controls are receiving much consideration, as are personnel training progress. A. H.

1185. New whipstock technique for hard rock drilling. C. P. Collins. *World Oil*, Aug. 1950, **131** (3), 114–20.—Whipstocking presents a more difficult problem in hard rock than in soft formations. When about 6 to 8 ft below the bottom of the whipstock the combination of hardness of formation and extra bit wt often causes the bit to break back towards the plug. Experiments have shown that a successful method is to use a diamond coring bit in conjunction with the whipstock until this critical 6 to 8 ft has been passed. To ream out this reduced-size pilot hole, a coring bit is used through which is dressed 18 to 20 ft of hydraulic tubing to act as a guide. Fluid forced through a hole in the foot of the tubing directs this to the side of the hole and thus finds the pilot hole. Relative cost data are given on conventional and coring methods of whipstocking on three jobs. A. H.

1186. Factors affecting penetration rate of rock bits. Part I. W. J. Bielstein and G. E. Cannon. *World Oil*, May 1950, **130** (6), 89–94.—Substantially as read before Spring Meeting S.W. District, A.P.I. Div. of Prod., Dallas. Tests, conducted in actual drilling wells, were carried out to investigate the effect of: (1) bit design, *i.e.*, number of wetting elements and distribution of fluid; (2) hydraulic factors; (3) rotary speed and bit weight on rate of penetration. To date tests were confined (*a*) to the softer rocks and (*b*) to medium-hard and non-abrasive formations. Graphs show the rate of penetration and bit weight (10,000 to 30,000 lb) for the different bits in the two formations. With some exceptions, depending on bit weight, jet-type bits ran faster than conventional bits. In jet-type high-fluid velocity nozzle is directed at the bottom of hole. In general, an increase in drilling rate accompanies each increase in circulation rate, however, it is apparent that the increase is small compared to the additional horse-power required. A. H.

1187. Estimation of interstitial water from the electric log. M. Williams. *J. Petrol. Tech.*, Oct. 1950, **2** (10), *A.I.M.M.E. Tech. Paper No.* 2936, 295–308.—Cores from two Woodbine sand wells at Hawkins, and from a Navarro well at Charlotte have been cut in oil-base mud, and carefully examined for resistivity, porosity, permeability, interstitial water, and salinity, and in some cases Mounce potential. In the former field the well was subsequently logged with water-base mud, but in the latter sliding electrodes were used. Salinities were found to vary appreciably in both sands. Estimates of water saturation were made from electric logs by conventional methods and compared with the core-analysis results. The square-root relationship between interstitial water saturation and true resistivity did not hold in this investigation. It appeared that the apparent resistivities of high-resistivity beds on electric logs made in ordinary mud were generally much lower than the resistivities measured on the cores. The methods used for deriving true resistivities from the apparent resistivities on logs made in ordinary muds are believed to be ineffectual. Water saturations derived from electric-log data should be used only as secondary standards. G. D. H.

1188. The rheology of suspensions. Application to drilling mud. R. Métrot. *Rev. Inst. franç. Pétrole*, Jan. 1951, **6** (1), 3–19.—The widely different results obtained from a study of the physical properties of a clay are largely due to the non-homogeneity of the system under study. Clays consist of anisotropic aggregates of lamellary particles.

Paper forms first part of a series dealing with the physical properties of drilling muds, and the theoretical treatment of rheological phenomena is described as a preliminary to the study of concentrated suspensions.

In order to explain the apparently anomalous properties of certain bodies, the behaviour of analogous mechanical models is described. C. A. F.

Production

1189. Gas lift: Principles and practice, Part 2. C. D. Fletcher. *World Oil*, Aug. 1950, **131** (3), 182–90.—The design and operation of pilot-controlled pressure-operated intermitting valves are discussed and illustrated. There are three distinct methods of designing the operating pressure of a valve string: (1) all valves set at successively

lower test-block closing pressures as they are placed lower in the string; (2) all valves set at the same test-block closing pressure; (3) all valves set at successively higher test-block closing pressures as they are placed lower in the string. Each method has its own advantages, which are discussed. Equations for computing spacing, quantity of air required, and pressure are given. A. H.

1190. Synthetic liquid fuels. Annual report of Secretary of Interior for 1950. Part IV. Oil from secondary recovery and refining. *U.S. Bur. Mines Rep. Invest.* 4773, Feb. 1951.—A summary is given of the research progress made in 1950 in the entire synthetic-liquid-fuels programme, Part IV, reports progress during the same period with respect to the following: engineering studies of secondary recovery in four regions, physicochemical studies of interfacial forces in relation to oil production, engineering studies of secondary-recovery problems, techniques and laboratory analyses for secondary-recovery research, and under petroleum chemistry and refining, sections covering the separation and identification, thermal stability, and thermal decomposition of sulphur compounds. The characteristics of distillates from high-sulphur crude oils are discussed. W. H. C.

1191. Illinois fluid injection research reviewed. F. Squires. *Producers' Monthly*, July 1949, **13** (9), 32.—The following production procedures as applied to oilfields in Illinois are reviewed: (1) cojoint injection of gas and water; (2) selective plugging with water; (3) flooding with old wells; (4) exploring with injected gas; (5) water encroachment tests; (6) use of special equipment to solve new conditions; (7) use of non-ferrous casings; and (8) thermal drives.

Cojoint injection of gas (into the uppermost parts of the structure) and water (into the lowermost parts of the structure) is only described briefly: it is aimed at maintaining reservoir pressure by downward movement of the gas–oil contact simultaneously with upward movement of the water–oil contact. Selective plugging with water in the gas-injection wells was found to reduce the permeability to gas and thus to inhibit gas channelling. The adaptation of old wells for gas and water injection in this manner is briefly discussed.

The distribution of permeable zones has been determined by measurements of output gas volumes, bottom-hole-pressure surveys, use of tracer gas, by comparison of pressure–volume relationships, and by measurements of speed of gas travel: each method is described briefly. Diagrammatic methods of determining the direction, speed, and results of edgewater encroachment are also shown.

Shot-hole calipers and shot-hole core-drills have been specially designed for use in this area, in the determination of permeabilities in old wells: a rotor valve has been designed for measuring and regulating the flow of water from an upper water sand into a lower oil sand. Other special equipment in use includes an acid drill, for horizontal drilling in limestone formation using acid as the circulation fluid, and a safety cyl, to reduce the danger of explosions when air–gas mixtures are injected into the formation. The operation of these devices is explained with the aid of diagrams.

Preheating of the injected gas has been used to counteract the cooling effect resulting from the expansion underground of the large volumes of gas injected. It has been found that this procedure not only reduces the visc of oil in the sand, thereby increasing production, but that it also results in the evaporation of lighter fractions from the residual oil which will be carried along in the gas stream. These fractions may be subsequently removed from the gas stream at the surface by counter current contact with stripped oil. R. B. S.

1192. The quantitative valuation of methods of procedure in water flood oil production. Part 1. H. M. Ryder. *Producers' Monthly*, July 1949, **13** (9), 20.—The method of quantitative valuation described is based on the analysis of decline curves: eleven decline curves of wells in the Eastern Kansas field are presented. The author shows that if these curves are plotted on log-log paper, they may be represented by the equation

$$P = At^b$$

where P = daily oil production rate b.d.;
t = time in months;
A = daily oil production rate at unit time, and
b = slope of decline curve.

Some of these curves are then analysed graphically and mathematically according to this equation, and the methods of estimating cumulative recovery and future production rates are shown. The application of these methods to production is discussed; the most serious limitation being that production data are required during operation of each of the several methods separately, and for an extended period of time.

Three references are appended. R. B. S.

1193. The quantitative valuation of methods of procedure in water flood oil production. Part 2. H. M. Ryder. *Producers' Monthly*, Aug. 1949, **13** (10), 16.—In this part the author discusses the use of the decline-curves equation proposed in Part 1 by constructing a hypothetical curve based on certain assumptions, the following being the most important: (1) the sand exists as a single layer; (2) there are three zones of fluid saturation (viz., watered-out sand zone, oil-bank zone, and undisturbed-oil zone) and the fluid saturations and effective permeabilities in each zone remain constant over the reservoir history; (3) water only drives oil ahead of it, so that oil and water do not flow simultaneously in a single pore; (4) fluid movement is parallel to the bedding planes; (5) the water flood pattern is uniform; (6) atmospheric pressure exists in the reservoir at the start of the flood, and in the producing wells at all times; (7) there is no discontinuity in the pressure gradient at the water–oil interface. R. B. S.

1194. Petroleum engineering study of the Weber pool, Washington County, Oklahoma. K. H. Johnston and C. W. Moot, Jr. *U.S. Bur. Mines Rep. Invest.* 4740, Dec. 1950.—The history, geology, development, and exploitation of the Weber pool, Washington Co., Oklahoma, are described. The pool extends from 2 miles east and slightly north of Bartesville, to about 2½ miles northeast of Dewey. The first well in Washington Co. was completed in 1897 and active development began in 1904. The Weber discovery well being completed in 1905, the field has been repressurized since 1926. Secondary development, vacuum operations, and eight air and gas repressuring projects, and four water-flooding projects are described and discussed. The total production to January 1950 from the area was approx 14,000,000 brl. The recoverable oil remaining in the Bartesville sand reservoir is estimated to be 18,000,000 brl. For its production it will be necessary to initiate additional secondary-recovery practices on some of the leases and the application of a more systematic repressurizing programme on others. W. H. C.

1195. Summary of water-flooding operations in Illinois. 1950. F. Squires *et al. Circ. No.* 165. *Reprint of Interstate Oil Compact Commission Report*, Sept. 1950.—Data are given of thirty-one controlled water-floods in Illinois. Up to Jan. 1, 1951, these operations had produced about 15,400,000 brl. of flood oil from sands averaging 20 ft thickness, requiring 10,000 b.d/ft water. Average porosities were about 20%, and permeabilitites were approx 150 mD. Fluid saturations at start were 64% oil and 20% water, and the ratio of water input to flood oil was 5 : 1 at the end of 1949. Overall recovery to 1.1.51, from 8450 acres, was 1213 brl/acre, and appeared encouraging with respect to the remaining 376,000 acres of the states oil-producing territory. Maps, data, and descriptions are recorded of the following: water floods: Siggins field, East, Clark, and Cumberland Co.; Maunie South field, White Co.; Bellair field, Crawford Co.; Ikemire-Henry lease, Crawford Co.; W. E. Robins Bridgeport, Lawrence field, Lawrence Co.; Pakota field. These are discussed as to: (1) similarities, and (2) the usefulness of the data as a basis for assessing water-flooding possibilities in other areas. W. H. C.

1196. Progress report on Penn Grade secondary recovery research. J. N. Preston. *Producers' Monthly*, July 1949, **13** (9), 15.—This report summarizes progress which has been made in the research projects sponsored by the Pennsylvania Grade Crude Oil Association.

The effect was studied of pressure gradient on the recovery from long, consolidated cores from the Venango sand and the Bradford sand. Experiments were carried out using live crude and natural brines and duplicating field conditions as far as possible: under these conditions it was found that higher recoveries are obtained at higher flood-pressure gradients.

Experiments on the effect of wetting agents on water-flood recovery show that

recovery is enhanced by "slug" feeding: for instance, it was shown that wetting agents which were absorbed by the sand from treated water could be later desorbed by subsequent flooding with untreated water. Tests on a Venango sand core have also indicated that alternate gas and water injection may lead to higher secondary-recovery efficiencies than straight gas or water drive.

Preliminary experiments on the effect of short-duration heat treatment on water permeability of sands have shown that during the heating period the permeability is actually reduced: after the heating period the permeability rises as the temp falls, and in some cases rises to a value in excess of its original value. These experiments imply that hot-water flooding would reduce water-intake rates; hot-water flooding has been practised in the past on the assumption that there is increased permeability to hot water. R. B. S.

1197. Increasing production by pressure cycling the pumping well. W. A. Hessin. *Producers' Monthly*, Sept. 1949, **13** (11), 15.—Data obtained from a Pennsylvania lease have established the fact that, for secondary recovery, pressure control is as essential, if not more important, at the producer as at the input well. The pressure cycling as practised on this lease consisted in the continuous input of air, and the periodic closing and releasing of producers. The procedure was based on the assumption that the higher pressure gradient between the input and producing wells would tend to force the pressure medium into the less-permeable sections. Although unorthodox, the production had been increased by 250% on one property; no appreciable increase in well-maintenance work was required.

Production graphs are given. A. J. H.

1198. Injectivity indices, their prediction and determination. N. van Wingen. *Producers' Monthly*, Aug. 1949, **13** (10), 27.—The development of an equation giving the subsurface injection pressure in terms of surface pressure, and gas characteristics and flow rate, facilitates the estimation of the injectivity indices. This method of obtaining the injectivity index is of particular application in fields where annular flow is prominent, and where the running of a bottom-hole-pressure bomb is not practicable, and in fields where high injectivity pressures and rates are found. The use of this index lies in the successful operation of a field: plugging of the sand face and an uneven intake profile are more easily located.

The equation is based on the energy loss due to frictional drag, and depends on the friction factor and gas constants. Although not rigorous, its application is justifiable for engineering calculations. A. J. H.

1199. Review of cycling operations in La Gloria field. W. H. Justice. *Petrol. Tech.*, Oct. 1950, **2** (10), *A.I.M.M.E. Tech. Paper No.* 2952, 281–6.—The La Gloria gas field is an elliptical dome with 350 ft of closure embracing 5500 acres. Gas occurs in twenty major sand zones in the lower Frio and upper Vicksburg. About forty wells have been drilled. The La Gloria zone is at 6515 ft in the lower Frio. It averages 32 ft in thickness. The gas column was 125 ft with no oil. Porosity averaged 22·2% and permeability 521 mD. Connate water was 20%, original pressure 3470 p.s.i.a., and temp 203° F. The original reserve was 139,284,000,000 cu. ft with 6,727,000 brl of condensate. Cycling operations began in 1941. During the first four years 50,000 M.c.f. was produced daily, but at present the rate is 21,000 M.c.f. 97% of the gas has been replaced through three wells. There has been little pressure drop, and retrograde loss has been largely prevented. The travel of dry gas was detected by testing each well every quarter. There was about 80% displacement of the wet gas in the invaded zone. The programme is estimated to be 95% complete, and ultimately it is expected 2,725,000 brl of condensate will have been recovered by re-cycling, while 836,000 brl will be recovered by depletion to 500 p.s.i.a. abandonment.

Tables give field and well data.

Cycling of the La Gloria zone has increased the ultimate condensate recovery, and provided a substantial income from what would otherwise have been a very low income property. G. D. H.

1200. Pressure distribution in unsaturated oil reservoirs. E. R. Brownscombe and F. Collins. *Petrol. Tech.*, Oct. 1950, **2** (10), 9–10.—The normal radial flow formula assumes constant pressures at the well and an external radius. However, in practice

when other wells are present there is no flow across the external radius which becomes a line of zero pressure gradient. The pressure must decline at the same rate at all points if flow is constant, and each unit of volume of oil is expanding at the same rate. The pressure distribution is given by

$$P = P_w \times \frac{\alpha\mu q_w \beta}{2\pi kh}\left[\log_e \frac{r}{r_w} - \frac{r^2}{2r_s^2}\right]$$

where a is a constant and h = pay thickness in ft, p = pressure at radius r ft in p.s.i.a., β = formation volume factor, q = well production in brl. G. D. H.

1201. Performance of limestone reservoirs. R. C. Craze. *Petrol. Tech.*, Oct. 1950, **2** (10), *A.I.M.M.E. Tech. Paper No.* 2935, 287–94.—60% of current oil production comes from carbonate reservoirs. The limestone voids are characterized by a wide variation in shapes and distribution of pore sizes; some types are similar to sandstone, but others differ widely, and it is then difficult to obtain representative samples for measurements.

In a study of 3700 samples from many places in North America and the Bahamas four basic porosity types were recognized—intercrystalline, intergranular, fissure, and vug. In the fracture-type well potentials were medium to high and less variable than for other types; a high degree of intercommunication was apparent. In the vug type potentials were widely variable, and intercrystalline types generally had lower and more uniform well potentials than the vug type.

In the Edwards limestone cores showed little oil when the porosity was under 5% and none at 2% and 0·01 mD permeability. In some Ellenburger dolomite cores taken with oil-base muds the water appeared to occupy practically all the matrix porosity, and oil all the fracture porosity.

Examples of dissolved-gas drive, gas-cap drive, and water-drive are given for limestone fields, and these are compared and shown to be similar to equivalent types in sandstones.

Active oil studies afford no evidence that delayed oil entry from low-permeability regions is of importance. Various studies have suggested that well spacing alone does not have any appreciable effect on ultimate recovery. Good completion practice in limestones requires drilling to the bottom of the productive section, and completion with the max interval necessary to give a satisfactory productivity factor. For water-drive the maximum efficient production rate is that which will keep the reservoir pressure at or above 70 to 80% of the initial or the saturation pressure.

The volumetric balance and unsteady state radial-flow equation, the fluid-displacement equation, use of electrical-analogue devices, and other analytical techniques to study the behaviour of limestone fields appear fundamentally applicable, but do require thorough understanding of the formation properties, fluids, etc., and adequate production-operating data. G. D. H.

1202. Multiple packing of input wells. W. A. Hessin. *World Oil*, Aug. 1950, **131** (3), 151–4.—A description of the equipment used, and the procedure of installation for pressure control of an actual five-zone input well now in operation. By proper surface regulation of input volumes the pressure medium is introduced to each section of the sand face, thus minimizing by-passing or channelling. A. H.

1203. Pumping equipment selection for lowering lifting cost. K. N. Mills. *World Oil*, July 1950, **131** (1), 139–45.—The choice of surface and subsurface lifting equipment can influence cost of producing an oil well. The probable production rate should be established before tubing is run into well, as this will determine max pump-bore size. When production rate is determined a practical combination of plunger dia, stroke, and pumping speed must be selected. Inertia forces place a limitation on speed. For normal friction maximum speed is given by $N = \frac{60{,}000}{L}$, where N = max strokes per min and L = length of stroke, inches. As most sucker-rod failures are the result of fatigue, max rod life is realized when operating at speeds below the max pumping speed. A chart shows relationship between range of stress and endurance limit. A production chart can be used to select stroke length, speed, and plunger combinations to give a desired rate of production. The various types of pumps are illustrated and their use discussed. Pumping power (H_p) required can be determined from the equation:

$$H_p = \frac{P \times D}{68{,}000 \times K}$$

where P = production rate based on 80% pump eff brl per 24 hr;
D = depth to pump, ft;
K = application constant for type of power used, values ranging from 0·85 to 1·0 are given.

The uses of normal and high-slip electric motors are discussed and compared.

A. H.

1204. Use of shaped charge process for open hole shooting. J. F. Gardiner. *World Oil*, Aug. 1950, **131** (3), 99–103.—By shaping an explosive charge the forces of detonation are focused at one particular point, and therefore are utilized in a very efficient manner. Type of gun and carrier and results of trial shoots are described. Cast iron is preferred to aluminium as carrier material, since the former breaks into smaller pieces, thus facilitating aftershoot cleaning. A. H.

1205. Improved method for measuring porosity of oilfield cores. C. G. Rall and D. B. Taliaferro. *Producers' Monthly*, Sept. 1949, **13** (11), 34.—The accuracy of determination of porosity is dependent on the accurate measurement of the volume of pore spaces and the bulk volume of the specimen. The principle of the method described consists in measuring at atmospheric conditions the volume of a gas previously held under pressure in the bomb containing the core specimen. By suitable correction of the gas volume, taking into account pressure, temp, and compressibility factor of the gas, the pore volume may be estimated to within a greater accuracy than possible with standard apparatus. The bulk volume of the specimen is determined with the aid of a stainless-steel pyknometer.

Detailed description is given of the apparatus, and of means of measuring pressure, which include the conventional dead-weight gauge, and a 100-inch mercurial manometer with periscope attachment for level measurement. Procedure and calculations are explained.

Reproducibility of results is good, and greater accuracy may be obtained by reducing the volume of the bomb with discs, or similar objects, when the size of the core permits. Accurate measurement of volume under atmospheric conditions is possible with a good burette; an auxiliary butylphthalate manometer ensures accurate levelling in the burette. Although the greater inaccuracy may occur in the determinations of the bulk volume, these may be within 0·2%.

Diagrams and references. A. J. H.

1206. Residual water and residual oil by capillary pressure technique. C. D. Stahl and R. F. Neilsen. *World Oil*, Aug. 1950, **131** (3), 160–3. (*Presented at 13th Annual Conference on Secondary Recovery, School of Mineral Industries, Pennsylvania State College.*)—Capillary pressure curves for a number of Bradford, Berea, and Venanzo cores were obtained. The experiments included displacement of water by oil followed by a water flood on the complex. The "irreducible minimum" water saturation for the Bradford cores was, in general, higher than the connate-water saturation found by routine core analysis. This was attributed to phase discontinuity and vanishingly small relative permeabilities at the apparently limiting saturations. A. H.

1207. Porosity-permeability check by electric log. R. C. Barber. *World Oil*, Aug. 1950, **131** (3), 165–75.—The application of the electric log to quantitative determinations of permeability and porosity in the Bradford field is discussed. A. H.

Oilfield Development

1208. 1950 world production up 11·1%. Anon. *World Petrol.*, Jan. 1951, **22** (1), 40.—World crude-oil output in 1950 was 3,785 million brl, 11·1% higher than the 1949 production of 3406 million brl. Average world daily production for December 1950 was 11,267,000 b.d. Increased production during 1950 was greater in the eastern hemisphere than in the western, but there were considerable increases in Canada, Mexico, and Venezuela. Production increase in the U.S.A. was 6·8%.

In the Middle East, which now produces 17·4% of the world's oil, production increased by 24·8% in 1950, aided by the enlargement of pipeline facilities.

U.S.S.R. production for 1950 is estimated at 754,000 b.d., compared with 690,000 b.d. in 1949.

Tables included show world cumulative oil production, proved reserves, and estimated ultimate production as at Jan. 1950 and Jan. 1951, by countries; and world crude production, 1939–50, by countries and percentage distribution of production by countries. C. A. F.

1209. Overdrilled Placerita Canyon nears exhaustion. D. H. Stormont. *Oil Gas J.*, 12.10.50, **49** (23), 82.—Production in the Juanita area of the Placerita Canyon field, California, has fallen considerably during the last year; some wells completed for over 2000 b.d. now produce 10 b.d.

The field has been overdrilled with a well density less than ½ acre/well. About 200 wells are currently producing, of which 160 cover 60 acres. Daily production reached a peak of 35,000 b.d. in Sept. 1949, and this has now fallen to below 12,000 b.d.

Casinghead gas has been wasted, and due to excessive producing rates G.O.R. increased from 200 : 1 to 1300 : 1, with a subsequent decline to 900 : 1 as the reservoir pressure fell.

Cumulative production of the field is 7,424,000 brl.

A structure map and production chart of the field are included. C. A. F.

1210. Oil and gas developments in Illinois during 1949. A. H. Bell and V. Kline. *Petrol. Tech.*, Oct. 1950, **2** (10), 167–208.—In 1949 Illinois produced 64,583,000 brl of oil. 2741 wells were drilled. 1408 found oil and seven gas. Twenty-four oilfields, sixty-nine extensions, and thirty-three new producing zones were discovered. 746 wildcats were drilled and ninety-three were successful. One Silurian and two Devonian pools were opened, while Devonian production was obtained in three old fields. Wildcat footage totalled 1,793,011 ft. New oil reserves are placed at 53,400,000 brl, while revision of old reserves should add 22,100,000 brl. 78·9% of the new reserves was in the Mississippian.

136,536,000 gal of natural gasoline and liquefied gas was obtained from about 13,500,000,000 cu. ft of casinghead gas. 9,500,000,000 cu. ft was used as fuel, and 3,100,000,000 cu. ft was returned to the ground. In addition, probably 45,000,000,000 cu. ft. of gas was not metered. 3,100,000 brl of flood-water oil was produced.

Tables present salient data on the fields, give the discoveries and extensions, summarize completion results since 1936, and summarize 1949 completions by fields.

A map shows the oil and gas fields, and indicates the 1949 discoveries. G. D. H.

1211. More reserves proved for Alberta. *Oil Gas J.*, 5.10.50, **49** (22), 287.—Proved oil reserves in Alberta are now estimated at 1·5 billion brl, of which Redwater, Leduc–Woodbend, and Golden Spike account for approx 85%. Gas reserves are estimated at approx 8 trillion cu. ft.

Nine wells have recently found oil production in the D_3 and D_2 and Cretaceous. 7 Big Valley, 15 miles south of Stettler produced over 1000 b.d. from the D_2 (39 ft) and 900 b.d. from the D_3 (11 ft). 1 Flint, 40 miles north of Stettler, flowed up to 700 b.d. from the D_2, and 1100 b.d. from the D_3. D_3 production has been found in three wells on a north–south line 5 miles west of Edmonton. In the Peace Creek area, 1 Whitelaw is producing 150 b.d. from the Permo-Pennsylvanian. Cretaceous gas has been found in a number of wells. C. A. F.

1212. Redwater now Canada's top field. J. L. Irwin. *World Petrol.*, Jan. 1951, **22** (1), 42.—The Redwater field, Alberta, now covers an area 14 miles by 4 miles and supports 700 producers. Proved reserves are 800 million brl, and a further 300 wells are expected to be drilled in the field.

The discovery well found 140 ft of pay with 35° oil, and was completed for an initial flow of 1728 b.d. By the end of 1948 seven wells had been drilled with a cumulative production of 36,875 brl. In Oct. 1950 the field was producing 54,202 b.d. from 665 wells. The eastern and western productive limits are now known: immediate development is expected in the southern section in the Simmons area.

Alberta's oil production in 1949 exceeded 20 million brl, and 1950 production is expected to exceed 25 million brl. C. A. F.

1213. Oil and gas developments in Venezuela during 1949. D. C. Porterfield. *Petrol. Tech.*, Dec. 1950, **2** (12), 452–5.—In 1949 Venezuela produced 482,339,000 brl of oil and at the end of the year the cumulative production was 5,003,932,000 brl. 682 wells were completed. 446 field wells yielded 430 producers; 236 wildcats gave 168 oil and four gas wells. Sixteen new fields were opened, seven being in the Greater Oficina area. CT-1 was abandoned at 15,637 ft on the southwest shore of Lake Maracaibo; Sibucara-5 was completed as an oil producer at 13,451 ft. Water-flooding was begun at Ambrosio and Oficina.

232 seismic party-months, 94·2 gravity, 1·2 magnetic, 34·5 structure-drill, and 259·4 surface geology party-months were worked in 1949.

Data on important wildcats are tabulated, and there are also data on the producing fields. G. D. H.

1214. Oil and gas developments in Trinidad during 1949. P. E. T. O'Connor. *Petrol. Tech.*, Dec. 1950, **2** (12), 449–51.—In 1949 Trinidad produced 20,693,334 brl of oil. 142 development wells were drilled, 130 being productive. At the end of the year 2304 wells were on production, and 655 were flowing. The Penal–Barrackpore field was extended by deep Herrera production at 8000 to 10,000 ft. A dry hole at Otaheite was abandoned at 12,161 ft.

Data on the fields are tabulated. G. D. H.

1215. Oil and gas developments in Germany during 1949. A. Bentz. *Petrol. Tech.*, Dec. 1950, **2** (12), 433–6.—In 1949 Germany produced 841,511 tons of oil, a post-war record. Developments at Georgsdorf, Emlichheim, and Lingen were of importance in this connexion. The Ruhlertwist–Ruhlermoor field was opened on an anticline 10 km long and 3 to 4 km wide; its proven reserves are 6,000,000 tons. A stratigraphic trap was found by Scheerhorn No. 1 between the Georgsdorf and Adorf anticlines. The oil is in the Bentheim sandstone, sealed by Middle Albian marls. The Suderbruck field was discovered on a deep-seated anticlinal structure between salt domes. It produces from the Cornbrash.

A table summarizes the salient data on the German oilfields. G. D. H.

1216. Oil and gas developments in Kuwait during 1949. Anon. *Petrol. Tech.*, Dec. 1950, **2** (12), 441–3.—Forty-nine wells were completed at Burgan in 1949, making a total of eighty-six, with sixty-one actually producing. 89,930,444 brl of oil was produced. Oil comes from three Middle Cretaceous horizons at 3500 to 4800 ft. A deep test is under way. G. D. H.

1217. Composite electrical and radioactivity log—Central Basin Platform in Permian Basin. P. C. Ingalls. *Oil Gas J.*, 19.10.50, **49** (24), 122.—Most of the fields discovered in the Permian Basin are concentrated on the Central Basin Platform, and many of these are large producers. Estimated ultimate recovery of the ten largest fields on the Platform exceeds 3 (U.S.) billion brl. Producing formations are Permian and pre-Permian sands, dolomite, and anhydrite.

The geological history of the area is briefly described, and a composite electrical–radioactivity log is included. C. A. F.

Transport and Storage

1218. Erection of two 25,000 cubic metre tanks. H. U. Freymark. *Erdöl u. Kohle*, 1951, **4**, 76–8.—Two 20,000-m³ steel crude storage tanks first erected in 1940 and later dismantled were re-erected with increased capacity of 25,000 m³ each. Illustrated description of fabrication and erection is given. Mention is made of foundations used, water tests performed, and corrosion discovered. Great size of tanks required careful solution of special problems, *e.g.*, type of roof finally chosen was orthogonal, sixteen-sector, vaulted fabrication; structural details of which are fully described. Work was completed within 7½ months. P. V.

1219. Underground storage of natural gas. W. R. Kubista. *World Oil*, Aug. 1950, **131** (3), 212–16. (*Presented before* 1950 *Short Course in Gas Technology, Texas College of Arts and Industries.*)—The number of storage fields has increased from twenty-four in 1939 to eighty in 1949, and it is estimated that the total stored gas as at Dec. 31,

1949 was 258 (U.S.) billion cu. ft. The factors to be studied when considering a field for storage purposes are discussed. In a recent study estimated costs of such a project were reported to range from 2 to 53 cents of M.c.f. (excluding compressing station and dehydration facilities). Past experience with gas migration has shown it to be advisable to obtain leases of boundaries considerably beyond the estimated reservoir limits. The use of old holes and the precautions to be observed with plugged holes are discussed. Under some instances it is considered by the author safe to operate at pressures considerably in excess of discovery pressure. However, two important factors should be considered: (1) the possibility of blowouts of plugged wells and (2) that reservoir gas temp is not so abnormally low that hydrates would form in wellhead equipment under outflow conditions. A. H.

1220. Measurement and control of high pressure gas. A. F. Kraus. *World Oil*, Aug. 1950, **131** (3), 205–8.—Natural gas is now being stored in depleted gas fields during the summer for winter use. Other methods include high-pressure storage and liquefaction. The orifice meter is the most widely used type of meter, its advantages outweighing its disadvantages. Schematic drawings of an automatic pressure controller and pulsation dampeners are given. Care has to be exercised in reducing high-pressure gas to low pressure, since the resultant drop in temp is liable to cause freezing and hydrate problems. A. H.

1221. Lightweight pipelines: Aluminium has come of age. W. B. Moore. *Oil Forum*, Feb. 1951, **5** (2), 47.—In the past four years 61,420 ft of aluminium pipelines has been incorporated in nine separate installations constructed for petroleum industry use. Aluminium has many advantages over steel when used for the transportation of oil, gas, and other fluids. There are nine stages in pipeline construction: (1) clearing right of way; (2) grading right of way; (3) stringing pipe; (4) ditching; (5) line-up, bending, and tacking; (6) welding; (7) cleaning, priming, painting, and wrapping; (8) lowering in; (9) backfilling and cleaning up. Of these only items (1), (4), and (9) are not affected by the material of which the pipe is made. The others show advantages in favour of aluminium. Compared with steel, aluminium is lighter, more flexible, can be welded more quickly, is resistant to corrosion, and has a lower coefficient of friction which will decrease pumping losses. Construction is generally cheaper with aluminium, particularly in aerial river suspensions. In a river crossing the same capacity of gas can be carried by an aluminium line weighing one-third that of steel. A. S.

1222. Shell Haven refinery uses "Durley Dome" foundations for large-diameter tanks. V. S. Swaminatham. *Oil Gas J.*, 22.2.51, **49** (42), 166.—The thin shell structure providing a foundation at economical cost with low deadweight for clay silt soils, used at Shell Haven, England, is described. G. A. C.

1223. Submersible tank-battery barge stores 4,800 brl of crude. Anon. *Oil Gas J.*, 22.2.51, **49** (42), 146.—The first practical submersible substitute for customary piling-supported wooden platforms designed for interim oil storage designed and built by Bethlehem for Gulf Refining Co. Ltd., is described.

Barge carries all necessary equipment on topside deck, pump, separators, etc.; and is in two parts, a submersible float into which water in introduced and the oil-storage tanks superstructure. G. A. C.

1224. Pipeline system of Middle East oilfields. Anon. *Times Rev. Ind.*, Mar. 1951, 6–7.—Existing lines are Tapline (30/31 inch) Abqaiq–Sidon (eventual capacity 25 million tons/year), Iraq pipeline (2 × 12 inch) Kirkuk–Haifa and Kirkuk–Tripoli of total capacity 4½ million tons/year, and an additional 16-inch line on Kirkuk–Tripoli section; a similar line on the Kirkuk–Haifa stretch at present stops short at the Israel frontier. When this last 50-mile section is completed total capacity of present lines from Kirkuk to the Mediterranean will be 12 million/tons year. A further line (30/32 inch) is under construction from Kirkuk to Banias (Syria), planned for additional 12 million tons/year and scheduled for completion in 1952. Plans exist for a line ("Mepline") from head of Persian gulf to Tartus (Syria), this would be 34/36 inch with capacity of 26 million tons/year; thus raising total possible deliveries to Levant seaboard to about 75 million tons/year. Map showing existing, constructing, and projected lines is given. V. B.

1225. Oil pipeline suspension bridge. Anon. *World Oil*, Aug. 1950, **131** (3), 203–4.—Photographs illustrate the type of construction used for a 24-inch pipeline bridge, whose total length is 2185 ft divided into three 600-ft spans. A. H.

1226. Elastic modulus determinations yield waterhammer data. Anon. *World Oil*, Aug. 1950, **131** (3), 216.—As part of a research programme of the Joint Surge Conference, Northwestern University's Technological Institute has released its findings on the "Water Hammer" phenomena. From "test bomb" experiments, the modulus of elasticity of various kinds of crude oils and gasolines from high to low pressures and from freezing to boiling points have been computed. This new data, which should reduce breakdowns, leaks, etc., due to pressure-wave surges, will be available to engineering organizations. A. H.

Refinery Operations

Refineries and Auxiliary Refinery Plant

1227. Utilization of purchased electric power in an oil refinery. A. J. Claes. *Oil Gas J.*, 15.2.51, **49** (41), 90.—The St Louis refinery of the Socony-Vacuum Co. purchases all the electric power it uses; and how this is utilized for processing, lighting, and control is described. The electrical distribution system and power-system operation are reviewed. Purchased power has satisfied all the refinery requirements. G. A. C.

1228. Air ejectors for condensing plant. Anon. *Mech. World*, 9.3.51, **129** (3347), 227.—Steam-operated air ejectors (vacuum pumps) are now chiefly used for condensing plants because of their advantages, such as simplicity and robustness. They have no moving parts, they can easily be included in the feedwater heating system, and they occupy but little space. Compression is generally carried out in two or three stages for the sake of greater efficiency, and similarly surface-type coolers are placed between the stages. Larger power-plant installations sometimes have duplicate three-stage air ejectors for each large-capacity turbine and a further booster to facilitate rapid starting. The latter is used only when starting the machine. Motor-driven rotary air pumps are not now in general use, in spite of the fact that they were very popular on the early power-plants. Curves are supplied which show the time taken to create vacuum with different types of ejector. The less efficient the ejector the shorter will be the time required to produce vacuum. A three-stage ejector is more efficient than a two-stage ejector, but it takes longer to produce a given vacuum. A. S.

1229. Fog formation in cooler-condensers. H. F. Johnstone, M. D. Kelley, and D. L. McKinley. *Industr. Engng Chem.*, 1950, **42** (11), 2299–302. (*Symposium on Sulphur, Amer. Chem. Soc.*)—Valuable or obnoxious materials may be emitted from cooler-condensers if fog-formation occurs. The conditions to produce such fog are analysed thermodynamically. Limiting conditions for the temp of the interface, gas composition, and temp in the condenser are related by a theoretical equation. This was experimentally checked, using mixtures of nitrogen and the vapours of S, *n*-butyl alcohol, and water. R. G. T.

1230. Importance of oilburner nozzles. Part II. Their effect on combustion. K. J. Whittet, H. G. Murray, and C. L. White. *Fueloil & Oil Heat*, Jan. 1951, **10** (1), 73.—A group of ten 1-gal nozzles were tested at pressures from 100 to 150 p.s.i. in a conventional gun-type burner and in a 100 sq. in. by 18-in high combustion chamber. Results indicated: (*a*) In general nozzles were poorly calibrated; (*b*) increasing pump pressure had no consistent effect on combustion characteristics; (*c*) increased pump pressure increased the fuel delivery of a nozzle about 4% for every 10 lb increase in pressure; (*d*) nozzles delivered more fuel as the visc of the fuel increased up to 50 SSU; (*e*) rises in nozzle temp decreased the fuel rate; (*f*) when setting a burner it was important to allow 10 to 20% excess air to hinder smoke formation; (*g*) nozzle pluggings could be reduced by proper cleaning and flushing of fuel systems; (*h*) nozzle coking was caused primarily by excessive nozzle temperatures combined with poor cut-off characteristics of the burner. D. K.

1231. Heat transfer in packed beds : Analytical solution and design method : Fluid flow, solids flow, and chemical reaction. E. Singer and R. H. Wilhelm. *Chem. Engng Prog.*, July 1950, **46** (7), 343–57.—An analytical treatment is presented of the transfer of heat in beds of packed solids with heat flowing through the container wall into a fluid flowing through the bed. The analysis, based upon four simultaneous mechanisms for heat flow, produces differential equations which have been solved for cylindrical beds. Design procedures based on the results are outlined and illustrative problems solved. J. G. H.

1232. Heat transfer, mass transfer and fluid friction—relationships in turbulent flow. T. K. Sherwood. *Industr. Engng Chem.*, 1950, **42** (10), 2077–84.—Present knowledge and theory relating the three interphase transfer processes of heat transfer, mass transfer, and fluid friction is outlined. Fluid flow in pipes is discussed in the light of the concepts of molecular diffusion, turbulence eddy diffusion. Theories of overall process of transfer from pipe wall to turbulent fluids are summarized. Typical data of the three processes are compared to show basic similarity and simplicity of their interrelation. R. G. T.

1233. Approximate solution of the problem of heat exchange under conditions of free liquid mobility with a laminar boundary layer at the wall. L. I. Kudryashev. *Izvest. Akad. Nauk S.S.S.R., Otdel. Tekh. Nauk*, 1951, 253–60.—Under conditions of free mobility examination of the convective heat exchange can be reduced to a study of the heat exchange at the thin boundary layer, where temp and velocity are very different from those in the surrounding area. A mathematical consideration of the problem shows that an expression suggested previously, and obtained on the basis of experimental data: $\overline{Nu}_m = 0{\cdot}54\ (GrPr)_m^{1/4}$ is, in the range $5{\cdot}10^3 < (GrPr)_m < 1{\cdot}10^7$, within 0·2 to 5·5% of the value obtained theoretically. Previous views regarding the small effect of body shape on the problem under consideration are thus confirmed. V. B.

Distillation

1234. Multicolumn reflux still. Anon. *Scientific Lubrication*, Aug. 1950, **2** (8), 27–8.—The principles of molecular distillation are outlined and its application to the separation of hydrocarbons remarked. Details of the construction and operation of a new multicomponent still designed at the National Bureau of Standards are presented and its advantages enumerated. J. G. H.

1235. Limiting flows in packed extraction columns. R. R. Brechenfield and C. R. Wilke. *Chem. Engng Prog.*, Apr. 1950, **46** (4), 187–94.—The mechanism of liquid-liquid extraction in packed columns is discussed, and details are presented of an experimental column built for the study of the effects of physical properties of the flowing fluids on limiting flows and the effect of interfacial tensions. Packings used were ½-inch carbon Raschig rings and ½-inch Berl saddles. The data so obtained are compared with results of previous work in order to evolve a correlation of value for extraction-column design. J. G. H.

1236. Batch rectification : analytical expressions for yield fraction of batch distillation with finite reflux ratio. J. C. Chu. *Chem. Engng Prog.*, May 1950, **46** (5), 215–20.—Using Smoker's quation and Eshaya's method analytical expressions are derived for binary mixtures giving the yield of distillate of a given composition obtainable by batch fractionation of a given charge in both an ideal column and a column with hold-up. It is assumed that the reflux ratio is continuously increased throughout the rectification to maintain the product composition constant with a finite reflux ratio at the cutting point. The application of the equations to complex mixtures, using Hengstebeck's proposed effective binary system is indicated. J. G. H.

1237. Batch fractional distillation—calculated and experimental curves for batch distillation with appreciable hold up. A. Rose, R. C. Johnson, and T. J. Williams. *Industr. Engng Chem.*, 1950, **42** (10), 2145–9. (*Divn of Industr. Engng Chem.* 113*th and* 116*th Mtgs Amer. Chem. Soc., Chicago and Atlantic City.*)—Equilibrium curves for batch distillation of binary mixtures involving appreciable hold-up and finite reflux

ratios are calc by a stepwise, plate-by-plate method. A remarkable similarity is observed between these curves and groups of experimental curves obtained under similar conditions. This similarity justifies efforts to find a more efficient procedure for the calculations. It is hoped to extend the range and degree of correspondence of the experimental and calc curves to allow prediction effect of hold-up in practical instances of batch distillation. R. G. T.

1238. Batch azeotropic distillation : effect of charge composition on recovery. L. Berg, H. C. Carpenter, and J. B. Daly. *Chem. Engng Prog.*, June 1950, **46** (6), 283–9.—Batch separation by azeotropic distillation of five different systems was investigated to determine the effect of charge composition on recovery of constituents. Separations investigated were methyl*cyclo*hexane from toluene, using 1-propanol as the entrainer, methyl*cyclo*hexane from toluene, using 2-butanone, *cyclo*hexane from benzene, using acetone, *n*-octane from ethylbenzene, using acetic acid, and ethylene dichloride from dioxane, using 1-propanol. It was observed that recovery of the less volatile component is independent of charge composition, while the recovery of the more volatile component increases as its proportion in the charge is increased. J. G. H.

1239. Vapour-liquid equilibria at sub-atmospheric pressures, tetradecane–hexadecane system. R. R. Rasmussen and M. van Winkle. *Industr. Engng Chem.*, 1950, **42** (10), 2121–4.—Vapour–liquid equilibrium data for the above system are presented at 10 to 760 mm abs pressure. Purity tests of components are quoted. Activity coeff are plotted and show that system is almost ideal by Raoult's law (especially at 200 mm). Thermodynamic consistency is shown by the use of modified Duhem equation. R. G. T.

1240. Mass-transfer resistances in Liquid–liquid extraction. G. S. Laddha and J. M. Smith. *Chem. Engng Prog.*, Apr. 1950, **46** (4), 195–202.—H.T.U. values for each liquid film were measured in a countercurrent liquid–liquid extraction column for the two systems, *iso*butyraldehyde–water and 3-pentanol–water. The 2-in I.D. column was operated in three ways; as a spray column, packed with ½-inch Raschig rings; packed with ¾-inch Raschig rings.

The H.T.U. of the discontinuous phase was found to be nearly independent of variations in the flow rates of either the continuous or discontinuous phase and of the three types of column operation.

The H.T.U. of the continuous phase was affected by both flow rates, but could be correlated with the ratio of the flow rate of the continuous-phase rate to that of the discontinuous phase. J. G. H.

Absorption and Adsorption

1241. Recovery and retention of light hydrocarbons. A. M. L. Kube. *Oil Gas J.*, 15.2.51, **49** (41), 98.—Some of the basic principles involved in the extraction of gasoline from natural gas are considered. The Kremser and Brown equation describing the absorption principle and the absorption system are fully discussed. Factors affecting fractionator capacity are investigated.

Twelve figures illustrate the article. G. A. C.

Cracking

1242. Silica–magnesia cracking catalyst—commercial performance. A. L. Con, W. F. Meehan, and R. V. Shankland. *Chem. Engng Prog.*, Apr. 1950, **46** (4), 176–86.—Results are reported of the first significant commercial operation of the fluid-catalyst cracking process employing silica–magnesia catalyst. With this catalyst, higher gasoline yields, lower butane and gas yields, and lower octane numbers were obtained than with silica–alumina. Advantages, including high-activity maintenance and immunity to sulphur poisoning, are balanced against an unfavourable trend towards decreased regeneration efficiency. J. G. H.

Hydrogenation

1243. Kinetics in tubular flow reactor; hydrogenation of ethylene over copper–magnesia catalyst. R. Wynkoop and R. H. Wilhelm. *Chem. Engng Prog.*, June 1950, **46** (6), 300–10.—Catalytic hydrogenation of ethylene over copper–magnesia catalyst was studied experimentally and theoretically as an example of application of chemical kinetics to a continuous-flow tubular reactor. Experimental conditions were varied over a considerable range; kinetic equations for the flow system were developed, and the experimental data were found to correspond to a first-order reaction with respect to hydrogen. Precision of measurement of rate constant is discussed, together with flow equations and precautions to be employed in their development, and a mechanism for the hydrogenation reaction is proposed. J. G. H.

Chemical and Physical Refining

1244. Deasphalting crude residuum for catalytic cracker—commercial production using horizontal settlers and propane solvent. E. C. Oden and E. L. Foret. *Industr. Engng Chem.*, 1950, **42** (10), 2088–95.—Operational data are presented for a commercial propane deasphalting unit, treating 20,000 b.d. of crude residuum. Products are cat cracked feed stock and asphalt. Effect of operating variables on quantity and quality of products is shown. Viscosity, S.S.U. at 210° F can be used to forecast approx yields. Critical settler temp is found above which the oil yield is not straight-line function of temp. Below the crit temp at constant visc of feed, oil yield decreases with increased settler temp. Critical settler temp affects the effect of propane : oil ratio or oil yield. The oil yield is directly dependent on average mol. wt. of solvent. Carbon residue and sulphur content data are discussed. R. G. T.

1245. Sulphur from sour gases—(Staff industry collaborative report). F. G. Sawyer, R. N. Hader, L. Hendon, and E. Morningstar. *Industr. Engng Chem*, 1950, **42** (10), 1939–50.—Importance of sweetening of sour natural gases for use as boiler fuel is stressed. Absorption sweetening methods are listed by which H_2S is removed from hydrocarbon gases. Regeneration of scrubbing solutions yields gas rich in H_2S, from which S can be removed economically, simultaneously solving the H_2S-disposal problem. The Mathieson process, based on the Claus–Chance process, effects S recovery by oxidation of H_2S to SO_2 and cat reaction of these two to give S. A process flow sheet and complete material balance are given for a Mathieson plant, whose operation is extensively described. Future prospects are discussed. R. G. T.

1246. Recovery of sulphur from synthesis gas. A. E. Sands and L. D. Schmidt. *Industr. Engng Chem.*, 1950, **42** (11), 2277–87.—(*Symposium on sulphur, Amer. Chem. Soc.*)—The sulphur content of synthesis gas for the Fischer–Tropsch process must conform to very rigorous requirements. Removal of bolt organic S and H_2S is necessary. H_2S removal is here discussed, and the methods of complete sulphur removal are assessed. Cost estimates are presented. R. G. T.

Special Processes

1247. Production of aromatics. C. H. Marshall, Jr. *Chem. Engng Prog.*, June 1950, **46** (6), 313–18.—The status of production of aromatic hydrocarbons over the period 1914–39 is summarized, and a description presented of the hydroforming process as operated by the Humble Oil and Refining Co. at Baytown, Texas. Flow sheets and operating details are included of wartime and post-war operation at this plant. J. G. H.

1248. Catalytic hydro-desulphurization of gas oil : analysis of the kinetics of the reaction. H. Hoog. *J. Inst. Petrol.*, 1950, **36**, 738–51.—The kinetics of this catalytic reaction $C_nH_mS_p + xH_1 \rightarrow C_nH_{m+2z-2p} + pH_2S$ have been analysed for the case of a Middle East gas oil, treated at 375° C and elevated hydrogen pressure in the vapour phase over a catalyst active for desulphurization by hydrogenation.

By comparison with two narrow fractions, cut from the original wide-range gas oil, it was found that the reaction may conveniently be described by a first-order

mechanism, but that considerable differences in reaction-velocity between the lighter and heavier sulphur compounds present in the oil prevent the calculation of an overall rate-constant. When considering only the initial reaction velocity it was shown that the rate constant is affected not only by the hydrogen partial pressure but also by the oil partial pressure. The addition of a supposedly inert diluent, nitrogen, to the hydrogenating gas was found to suppress the reaction velocity at constant hydrogen partial pressure. An explanation for these effects is put forward. A. R. W. B.

1249. Survey of filtration theories. K. Rietema. *Ingenieur*, 26.1.51, **63** (4), Ch. 1.—The paper opens with a definition of the operation, and mentions in the introduction the two main filtration theories. These are "blocking filtration" and "cake filtration." In considering the first theory, the work of (*a*) Hermans and Bredée, and (*b*) Heertjes and Van de Haas is dealt with, and it is concluded that general laws on blocking filtration cannot be laid down, because any form of blocking filtration will invariably be influenced to some degree by cake filtration, or a different form of blocking filtration.

In developing the cake-filtration theory the author derives an equation which is based on the cake build-up and the pressure distribution through the cake. This equation is valid both for compressible and incompressible cakes. Kozeny's equation for the relationship between the permeability and porosity of compressible cakes gives the dependence of filtration rate on the porosity distribution in the cake. Several forms of compressibility are discussed, and the scouring and filter effects are mentioned.

In conclusion, some reference is made to the experimental side of the subject and the relationships that can be derived from the results obtained. R. R.

Metering and Control

1250. New formulae for water flow pipes. Anon. *Mech. World*, 9.3.51, **129** (3347), 222.—Four new formulæ for water flow in pipes have been evolved in the engineering research department of Stewarts and Lloyds Ltd. as a result of extensive investigations of water-flow formulæ and test data on water mains and experimental test pipes. These formulæ have been accepted by a committee of the British Hydromechanics Research Association. They apply to pipes in new condition using water at normal temp, and cover all classes and sizes of pipes and a very wide range of velocities. A table gives the formulæ in various forms so that the hydraulic mean radius, hydraulic gradient, bore, or g.p.m. can be obtained directly. Allowances are made for secondary losses using the formula-head loss $h_s = \frac{KV^2}{29}$. A comprehensive list of values for K is given, which covers entry and exit losses, changes of bore, valves, bends, branches, and joints. A. S.

Products

Chemistry and Physics

1251. Institute of Petroleum Hydrocarbon Research Group Annual Report, October 1949–September 1950. B. W. Bradford. *J. Inst. Petrol.*, 1950, **36**, 752–4.—Reports of the year's activities of the hydrocarbon synthesis panel, the spectroscopic panel, and the mass spectrometry panel are presented. A. R. W. B.

1252. Evaporation rate of hydrocarbons and their mixtures. L. S. Galstaun. *A.S.T.M. Bull.*, Dec. 1950 (170), 60–9.—Results are reported of a study of the basic variables which affect the evaporation rate of hydrocarbon substances. The initial investigation covered a wide range of pure hydrocarbons, including straight- and branch-chained aliphatics, aromatics, and naphthenes. The apparatus and test conditions employed are outlined, and complications encountered in dealing with mixtures are discussed. For pure hydrocarbons the evaporation rate was found to be a function of the vapour pressure and heat of vaporization at the liquid temperature, the difference in temp. between evaporating liquid and ambient air, the velocity of air past the evaporating surface, the thermal conductivity of air at ambient air

temp., and the area of the evaporating surface. Hydrocarbon mixtures can be compared almost exclusively by their A.S.T.M. distillations. J. G. H.

1253. Thermodynamic properties of *n*-heptane. E. B. Stuart, K. T. Yu, and J. Coull. *Chem. Engng Prog.*, June 1950, **46** (6), 311–12.—Thermodynamic properties of *n*-heptane have been calculated from P.V.T. data and presented in a pressure–enthalpy diagram as well as in tabular form. Range covered is from 1 to 300 atm and from 209·08° to 1800° F. J. G. H.

1254. Burning velocities of propane–air mixtures. F. H. Garner. *Fuel*, Mar. 1951, **30** (3), 63–6.—Determinations of the burning velocities of propane–air mixtures have been made by the method described in an earlier paper. The results are compared with those by various workers using several different methods. The curves show wide differences, which are discussed with respect to the following: pressure and temperature, composition of the propane used, and the methods of evaluating the burning velocities. It is concluded that before real progress can be made in elucidating the mechanism of flame propagation, a method evaluating true burning velocity must be developed. By evaluating burning velocities from the Schlieren cone of a flame burning on a nozzle with constant velocity of flow, good results might be obtained, particularly if the angle measurements are confined to a central region so as to avoid the disturbances at the tip and base of the flame. Fifteen references are given.
W. H. C.

1255. Micelle formation of sulphonates in hydrocarbons. M. van der Waarden. *J. Coll. Sci.*, 1950, **5**, 448–57.—The visc at low rates of flow of a mixture of naphthasulphonates with the cations Na, Li, K, Mg, Ca, and Ba have been determined in various hydrocarbons and mineral oils of measured structure. The results are interpreted in terms of voluminosity (V) according to Eilers' equation:

$$\eta_r = \left(\frac{1 - 0{\cdot}1VC_v}{1 - 1{\cdot}35VC_v}\right)^2$$

where η_r is the relative viscosity and C_v is the volume concentration of dry dispersed naphthasulphonates. V passes through a max as the concentration is increased. It decreases as the temp is increased and as the aromatic content of the hydrocarbon medium rises. It increases with the mol. wt. of the hydrocarbon medium, and in the cation sequence H, Li, Na, K, or Mg, Ca, Ba.

It is concluded that the naphthasulphonates are dispersed in the hydrocarbon medium as laminar micelles with the polar groups inside. The comparative dimensions of the micelles can be estimated.

The stream double refraction of sodium naphthasulphonate in *n*-heptane and toluene at various concentrations has been determined. H. C. E.

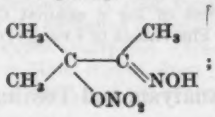
1256. Rate of sulfonation of benzene with sulfuric acid. R. C. Crooks and R. R. White. *Chem. Engng Prog.*, May 1950, **46** (5), 249–57.—The rate of sulphonation of benzene at a fugacity of one atm by H_2SO_4 was determined in a steady flow apparatus at temp from 90° to 140° C in reaction mixtures containing from 2·53 to 41·83 wt % $C_6H_5SO_3H$, and from 49·17 to 81·53 wt % H_2SO_4, with mass transfer effects eliminated by maintaining high agitator speeds. It appears from the results obtained that the concept of anhydrous sulphuric acid is useful in correlating the rates of sulphonation of aromatic hydrocarbons and that a similar concept may be applied in correlating nitration reactions. J. G. H.

1257. Dithionethiophanes. W. Friedmann. *J. Inst. Petrol.*, 1951, **37**, 40–3.—In the course of a re-examination of the reaction taking place, under certain conditions, between 2 : 2 : 4-trimethylpentane and sulphur, two isomeric compounds $C_8H_{12}S_3$ have been isolated. One of the isomers, m.p. 86° C, may be considered as belonging to the dithione–thiophane series; the other isomer contains a sulphydril group, as ascertained by alkaline sodium nitroprusside and by infra-red absorption spectrum. A. R. W. B.

1258. Catalytic hydrodesulphuration of gas oil. Contribution of hydrofining studies to the clarification of the structure of the sulphur compounds present in gas oil. H. Hoog. *Rec. Trav. chim. Pays-Bas*, 1950, **69**, 1289–96; *Rev. Inst. franç. Pétrole*, 1951, **6**, D.31.—Desulphuration of mineral oils by cat hydrogenation may give clues as

to the nature of S compounds present in the oil. Pure synthetic S compounds were decomposed by hydrogenation; reaction was limited to a rupture of C–S bonds and to saturation by H of free valencies. Cat used (Co/Mo) favours hydrogenation of the aromatic nuclei present in the S compounds. Residual products from the hydrogenation of a Middle East gas oil had only traces of materials with b.p. $<200°$ C, showing absence of sulphides and polysulphides in the gas oil. Mercaptan derivatives were absent, hence S derivatives of this gas oil must be of the thiophene or thiophane type. By hydrogenating a concentrate of S compounds obtained by HF extraction and chromatographing the product there was yielded 60% of aromatic hydrocarbons, 40% of naphthene hydrocarbons, and traces of acyclic hydrocarbons. Thus the original thiophenes and thiophanes cannot be alkyl-thiophenes or alkyl-naphthalenes. These original compounds are probably made up of 30 to 40% of thiophenes or thiophanes containing a homocyclic ring and 70 to 60% of thiophenes or thiophanes having two homocyclic rings. No conclusions could be drawn concerning the proportion of aromatic and naphthalene rings in the original S compounds. V. B.

1259. Addition of N_2O_4 to olefinic double bonds. H. Weghofer. *Erdöl u. Kohle*, 1951, **4**, 1–3.—Addition of N_2O_4 to 2-methylbutene-2 was investigated and the structure of the products clarified. Similar reactions with Fischer–Tropsch olefins are described. Carefully purified reactants were used, the N_2O_4 being re-distilled several times in a stream of O_2 and condensed with liquid air to colourless crystals. The 2-methylbutene-2 was cooled to $-60°$ C and N_2O_4 added to give 42% of a crystalline product (d. 97° to 98° C) identified as trimethylethylenenitrosate, viz.



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the remaining 58% of product was a lye-soluble oil. With the Fischer–Tropsch heptane–heptene fraction a reddish oil separated out, identified as a nitrol-alcohol. The nitro group is irreducible; the hydroxyl group can be oxidized to a keto group and the resulting keto-nitro compound easily reduced to corresponding amino compounds; as a result of further experiments a chelate bond is suggested. The varying proportions of products with different temperatures are given, as also are some of the reactions of Fischer–Tropsch nitro-alcohols, such as refluxing under vacuum with paraformaldehyde with subsequent halogenation, formation of soluble azo-compounds, and the preparation of metallic salts. The possible technical utilization of these products should be investigated. P. V.

1260. Synthesis of fluorocarbons, perfluoroalkyl iodides, bromides and chlorides and perfluoroalkyl Grignard reagents. R. N. Haszeldine. *Nature*, 1951, **167**, 139.—When $C_2F_4I_2$ is heated with $CF_2{:}CF_2$ polymerization occurs and the compound $I(CF_2CF_2)I$ is obtained in high yield. It is also formed when $CF_2{:}CF_2$ and I_2 are heated under pressure, and in both cases the members of the series $I(CF_2CF_2)_nI$ are formed in amounts dependent on temp and pressure. A member of this series can be converted into the next higher member by reaction with $CF_2{:}CF_2$. A reaction mechanism involving free radicals is proposed.

Lower members of the series $I(CF_2CF_2)_nI$ are liquids, and the higher ones are waxy solids. The compound $C_2F_4I_2$ is the least stable, but in all the C–I bonds can be broken by heat or ultra-violet light.

Compounds $CF_3(CF_2)_nI$ can be obtained by treatment of $I(CF_2CF_2)_nI$ with IF_5, SbF_5 or F_2 in N_2. Both of these series of compounds are converted by passage over CoF_3, or by pressure, into the fluorocarbons C_nF_{2n+2}. The lower members ($n \leqslant 3$) of the series $CF_3(CF_2)_nI$ form Grignard reagents which appear to behave normally to give ketones, acids, etc. The I atoms in $I(CF_2CF_2)_nI$ can be replaced by Br or Cl.

Mixtures of long-chain fluorocarbons and fluorochlorocarbons in varying amounts give oils, greases, and waxy solids having the stability of the constituent compounds. H. C. E.

1261. Measurements of contact potentials at the oil–water interface. J. T. Davies. *Nature*, 1951, **167**, 193.—Due to the diffusion of traces of ions into the oil layer, measurements of change in contact potential ΔV at an oil–water interface are not usually accurate. The use of petrol ether (B.P. 120° C) provides an insoluble oil film, but the resistance is then so great that A.C. measurements must be employed. In these experiments this has been done with the aid of a 2-cm gold disc vibrating with amplitude $<0{\cdot}1$ mm when immersed to within 0·5 mm of the water surface, and using a tuned-amplifier circuit for measuring ΔV to an accuracy of 0·3%.

This apparatus has been used to study the insoluble films formed at the oil–water interface for the quaternary ions $C_{18}H_{37}N(CH_3)_3^+$ and $C_{26}H_{53}N(CH_3)_3^+$. H. C. E.

1262. Rheology of suspensions of high solid concentration. P. J. Rigden. *Nature*, 1951, **167**, 197.—The influence of the physical properties of the separate solid and liquid phases on the flow properties of the solid-in-liquid suspension at high solids concentration has been investigated. The concentrations used are such that the void space in the dry, compacted solid is just filled with liquid. The visc of these suspensions were measured in a constant-load cylinder-compression test.

The mean pore radius ($\bar{r}$) of the pores constituting the voids was obtained by measuring the rate of flow of air through the dry, compacted solid under a known pressure gradient over a range of pressures, and calculating $\bar{r}$ from the Poiseuille–Knudsen equation for gas flow through a capillary.

When the voids are filled with liquid the pores of the solid become the filaments of the liquid, and the volume of the pores and the pore size should be related to the relative visc of the suspension. With bitumen as the liquid phase and a range of mineral powders as solids, a plot of log η against $C_v/\bar{r}$ (C_v = solids concentration) gives a promising correlation. The values of $\bar{r}$ range from 0·4 to 4μ. H. C. E.

Analysis and Testing

1263. Rectification column for petroleum process laboratory. K. W. Scheider. *Erdöl u. Kohle*, 1951, **4**, 4–9.—Steel rectification column is described containing a distillate distributor arrangement to give constant R.F.R. Apparatus is claimed to be suitable for dist between 10 mm and 45 atm. Construction and operation are simple, and reasonably reproducible dist curves are obtained. A wide pressure range is possible so that low-boiling components may be fractionated without additional cooling being necessary, as well as benzine to gas oil fractions separated. The reflux regulator is described in detail, its disadvantage is that the load on the column decreases as dist proceeds under constant R.F.R. Dist curves are plotted for experimental runs at 45 atm, atm pressure, and vac. P. V.

1264. Thermodynamic principles of a new fractionation method (step-wise separation). H. Trenne. *Erdöl u. Kohle*, 1951, **4**, 63–6.—Method (new in application but not in principle) consists of production of partial condensates in the column, separation from their vapours, and the further dist of separate condensates collected at the various stages. Advantages of the step-separation procedure over other columns, such as the Stedman, are discussed. However, less rectification is achieved than in such other types, and its limitations and possibilities are noted. Comparison is made with azeotropic dist processes, and a new method is given for the characterization of multi-component systems. The significance of phase equilibria and planes of separation is considered. It is concluded that, as a result of the contacting of condensate with the lighter volatile vapours in the column, a double heat loss occurs at every such contact surface through a displacement of the system equilibrium. These heat losses are suitably minimized in the column. Overall column ht can be considerably reduced, and it will be possible to increase the throughput and thus to save heat. P. V.

1265. X-Ray methods in the analysis and preparation of leaded gasoline. H. A. Liebhofsky and E. H. Winslow. *A.S.T.M. Bull.*, July 1950 (167), 67–73.—The determination of T.E.L. fluid in leaded gasoline by methods involving the absorption of X-rays can be effected in several ways. Experimental results are given for the determination, based on the absorption of polychromatic X-rays by the sample, the intensity of the emergent beam being measured by photoelectric methods. Methods are dis-

cussed for determination when parent base stocks are available, or unavailable and unknown. A brief description is presented of a method in which the automatic blending of base stock and T.E.L. fluid is controlled by the General Electric X-ray photometer. J. G. H.

1266. Optical investigation of hydrocarbons. VI. Raman spectra of aromatic hydrocarbons. P. A. Bazhulin and collaborators. *Izvest. Akad. Nauk S.S.S.R., Otdel. Khim. Nauk*, 1950, 501–5.—Raman spectra were measured for ten aromatic hydrocarbons boiling in range 80° to 160° C (benzene, toluene, ethylbenzene, *o*-xylene, *p*-xylene, *m*-xylene, *n*-propylbenzene, 1-methyl-3-ethylbenzene, mesitylene, 1-methyl-4-ethylbenzene). Accuracy was better than 1 cm^{-1} for the sharp lines and 3 cm^{-1} for the more diffuse. Spectrograph had dispersion (at $\lambda = 4373$ Å) of 10·9 Å/mm, line intensity was determined by photographic photometer, except for very weak lines, which were estimated visually. Intensity of the stronger analytical lines for aromatic, naphthenic, and paraffin hydrocarbons is in approx ratio 15 : 3 : 1. V. B.

1267. Analysis of detergents. Anon. *Soap*, Dec., 1950, **26** (12), 69.—A procedure for the analysis of synthetic detergents. The method is based on extraction of active material with alcohol after the sample has been dried by heating at 105° C, if a powder; or by azeotropic distillation if a solution. The additives, or builders, present are analysed separately. O. M.

1268. Method for evaluating the oxidation stability of inhibited transformer oils. G. H. Beaven, R. Irving, and C. N. Thompson. *J. Inst. Petrol.*, 1951, **37**, 25–39.—A method is described for the evaluation of the oxidation stability of inhibited transformer oils by measurements of their rates of oxygen absorption. Under the experimental conditions described the oxygen absorption/time curves show well-defined induction periods before the onset of oil oxidation proper, and the consequent formation of appreciable amounts of acid and sludge.

The induction period is taken as being an important criterion in the evaluation of inhibited oils, and is considered to be a measure of the susceptibility of an oil to any particular oxidation inhibitor. Data are presented showing: (*a*) the response, to a particular inhibitor, of transformer oils of varying degrees of refinement, (*b*) the response of a particular oil to varying concentrations of inhibitor, and (*c*) the relative effects of different inhibitors. An important result arising from this work is that a correlation has been established between tests involving the use of soluble copper and solid copper catalysts respectively. A. R. W. B.

1269. Suggested relocation and respacing of the union colorimeter scale for lubricating oil and petroleum. D. B. Judd, L. Plaza, and M A. Belknap. *A.S.T.M. Bull.*, July 1950 (167), 63–7.—From a study of the chromaticities and daylight transmittances of petroleum products a recommended relocation of the A.S.T.M. Union colorimeter scale has been derived which is intended to minimize the differences frequently experienced in the colour grading of " off-colour " petroleum products. Discrepancies in colour grading were also revealed between laboratories, ascribable to failure of the glass colour standards of the various Union colorimeters to conform to the master standards. It has been possible to respace the colour standards along the relocated locus by changes smaller than these interlaboratory discrepancies so as to yield uniform colour steps as perceived by the eye under standard conditions of observations. J. G. H.

1270. Method for testing high temperature performance of greases. W. J. Finn. *Institute Spokesman*, Dec. 1950, **14** (9), 7–18.—The increasingly severe conditions encountered by grease as a lubricant under modern conditions are remarked, and the necessity for arduous testing under simulated service conditions is stressed. Details are presented of a test unit developed by the Texas Company, consisting of a test bearing mounted on a spindle supported on suitable anti-friction bearings and driven by an electric motor by means of a flat belt. Special loading, housing, and temp-measuring features are described, and test procedure briefly outlined. A series of photomicrographs illustrates the conditions of the grease at failure. J. G. H.

1271. Evaluation of quality of paraffin wax. F. H. Maclaren. *Industr. Engng Chem.*, 1950, **42** (10), 2134–41 (*Divn of Pet. Chem. 116th Mtg Amer. Chem. Soc. Atlantic City, N.J.*).—A new breaking-strength test for paraffin wax is claimed to be simple and easily reproducible. Excellent correlation is obtained with laboratory test data for sealing strength and blocking. Index values (by the present test) and tensile strength values are compared. Blocking resistance, sealing strength, and tensile strength vary inversely with apparent oil content of the wax. The lab tests are indicated by parallel service behaviour of waxed paper. R. G. T.

1272. Determination of the ring and ball softening point of asphaltic bitumens with and without stirring. C. J. Krom. *J. Inst. Petrol.*, 1950, **36**, 727–37.—In the determination of the softening point of asphaltic bitumen according to I.P. 58/44 mechanical stirring in the bath is prescribed which is not the case in the normal A.S.T.M. method D36–26. The investigation reported shows that stirring the bath reduces the R. and B. softening point for all bitumens by 1·6° C both in the case of determinations in the water-bath and in the glycerine-bath, and consequently, that if stirring were generally applied it would involve alterations in all specifications with R. and B. limits.

Statistical calculations have shown that the repeatability of the R. and B. determinations with stirring is not better than that of the determinations without stirring, and it is therefore concluded that there is no reason for stirring the bath during this test. A. R. W. B.

Engine Fuels

1273. National motor-gasoline survey, summer 1950. O. C. Blade. *U.S. Bur. Mines Rep. Invest.* 4765, Dec. 1950.—The properties of premium and regular motor gasolines sold in the United States during the summer of 1950 for the various States are recorded, and their main characteristics are discussed. Comparisons are made with the data given in earlier winter and summer summaries. Octane numbers increased to new record levels, the values showing increases of 1½ to 2 O.N. over those of the previous summer. Average O.N. for premium gasoline were 90 and 82, and for regular gasolines; 83·5 and 78·2, by research and motor methods, respectively. A slight trend is shown towards higher volatilities over those of the last four summers. W. H. C.

1274. Comparative operating data of tractors using gasoline or L.P.G. fuel. M. J. Samuelson. *Oil Gas J.*, 8.2.51, **49** (40), 76.—The first of three articles comprising a symposium of portions of three papers on "Liquefied petroleum gas as tractor and automotive fuel," presented at S.A.E., Detroit, Jan. 1951.

The physical properties of propane, *iso*butane, *n*-butane and gasoline are tabulated; and graphs show fuel (gal/h.p. hr.) for gasoline and L.P.G.

Fuel consumption is higher for L.P.G. than gasoline at all compression ratios at max operating load, but less than that of gasoline (including 91 octane gasoline) at lighter loads. G. A. C.

1275. Pathfinding in fuels and engines. T. A. Boyd. *S.A.E. Trans.*, Apr. 1950, **4** (2), 182–95.—The search for an effective anti-knock compound is treated historically, and details are presented of the commercial development of T.E.L. Subsequent investigations of the structure of fuels and its effect on knocking behaviour are described, leading up to work on the sensitivity of hydrocarbons and the introduction of triptane. Recent work on high-compression engines and on the mechanism of combustion is considered, and directions for further research are indicated. J. G. H.

1276. Ignition of fuels by rapid compression. C. F. Taylor, E. S. Taylor, J. C. Livengood, A. W. Russell, and W. A. Leary. *S.A.E. Trans.*, Apr. 1950, **4** (2), 232–74.—Results are presented of investigations conducted in the Sloan Laboratory of M.I.T. using a rapid compression machine. The historical background of ignition study using compression engines is sketched, and the apparatus and procedure employed in the present investigations are described in some detail. Factors affecting the precision of pressure time records are discussed, and the behaviour of T.E.L. as a knock inhibitor and ethyl nitrate as a knock inducer are studied. High-temperature flame photographs are presented for each of the fuels used—benzene, normal heptane, *iso*-

octane, and triptane—under a variety of conditions. Other points considered include two-stage auto-ignition, relation of results obtained to detonation in an engine, and the limitations of photography as a tool for the study of combustion. Phenomena which it is considered need further investigation are enumerated. J. G. H.

1277. Ignition of methane–air mixtures by rapid compression. A. Egerton, N. P. W. Moore, and W. T. Lymm. *Nature*, 1951, **167**, 191.—Experiments on the spontaneous ignition of hydrocarbon–air mixtures by adiabatic compression were carried out in a motored engine in which the C.R. could be varied continuously between 4 and 28 : 1 while the engine was running. The combustion space and cyl bore could be seen through windows, and the combustion-chamber pressure was recorded with a cathode-ray oscilloscope.

Methane ignites in two distinct ways. A blue flame occurred at 16·8 : 1 C.R., mixture strength 70% of " correct " value. The pressure at the end of combustion was 37 atm, and the pressure records showed a much-delayed pressure rise. A more intense white flame occurred at 23·6 : 1 C.R., and the engine fired regularly. At intermediate C.R.s both types of flame were observed.

Similar results were obtained for propane and *n*-heptane. H. C. E.

1278. Combustion of fuel droplets. S. Kumatai, H. Isoda; and G. A. E. Godsave. *Nature*, 1950, **166**, 1111.—As in Godsave's experiments (Abs. No. 329, 1950) the time of burning of a fuel droplet (T) is proportional to the square of the initial dia (d) of the droplet over the range 1·3 to 0·3 mm. The specific burning time T/d^2 is used to compare the life of droplets, and it is found that when Pt is substituted for silica as a support for the droplet T is decreased. This is attributed to catalytic combustion.

[Reply by S. A. E. Godsave]: The constant T/d^2 is the inverse of the evaporation constant λ. The decreased burning times with the use of Pt supports may be due to the greater rate of heat transfer from the droplet. H. C. E.

1279. Engine and carburetion equipment requirements for L.P.G. fuel. A. J. St. George. *Oil Gas J.*, 8.2.51, **49** (40), 77.—Requirements for utilization of L.P.G. are discussed, and a flow diagram for butane–propane fuel engine application is given. The arrangement includes a high-pressure regulator, a vaporizer heated by hot water from engine, a low-pressure regulator, and carburettor. G. A. C.

1280. L.P. gas for motor fuel. R. C. Alden and F. E. Selim. *Oil Gas J.*, 8.2.51, **49** (40), 78.—Advantages and disadvantages of L.P.G. as a motor fuel are analysed. An ideal manifold distribution for air and fuel is shown. Availability of L.P.G. and its future potential supply and demand, prices, and conservation are discussed.

Conclusion is reached that although circumstances may retard direct use of L.P.G. as a motor fuel, both immediate and long-range potential availability will suffice for a practical development programme. G. A. C.

1281. Composition of diesel exhaust gas. M. A. Elliot and R. F. Davis. *S.A.E. Trans.*, July 1950, **4** (3), 330–46.—The relation between fuel/air ratio and the products of incomplete combustion is discussed, together with the probable origin of these products. A relation between the concentration of aldehydes and the odorous and irritant character of exhaust gas was observed, and led to the theory that the removal of aldehydes would reduce these properties. Tests with water as a scrubbing medium showed only incomplete removal; this could, however, be affected by the use of aqueous sodium sulphite solutions inhibited by the addition of hydroquinone, resulting in significant reductions in odour and irritation for extended periods. The application of the data so obtained to the determination of operating and performance data is discussed, together with methods of calculation. J. G. H.

1282. Fuel testing in gas turbines. K. J. Mackenzie and J. H. Boddy. *Airc. Engng*, Feb. 1951, **23** (264), 40.—Estimations of performance of a gas-turbine fuel using a single combustion chamber test unit have in the past shown a lack of repeatability difficult to ascribe to normal experimental errors only. Among possible sources of error is the uncontrolled variable of atmospheric humidity; average specific humidity in the British Isles is 0·006 lb water/lb dry air, while maximum is 0·020 lb water/lb dry air. Effects of atmospheric humidity variations on combustion chamber testing and operation are examined, the problem being considered from the point of view of air

flow measurement, calculation of combustion efficiency, and combustion processes. Correction factors are given to cover the expected range of variation in the British Isles. Calculations show the errors which arise if no account is taken of humidity changes when calculating mass flow with either an orifice meter or a pitot static tube. Humidity changes will not introduce errors into the estimation of combustion efficiency by exhaust gas analysis method, but heat balance method depends on estimation of specific heat of the exhaust products, and so must be affected by humidity of inlet air. Influence of water vapour on combustion reactions is discussed and attempts made to predict resulting effect on combustion chamber performance. Of the performance characteristics (1) degree of heat release at combustion outlet, (2) stable burning limits, and (3) outlet temperature distribution, it is shown that weak stable burning limits are likely to be affected to greatest degree. It is not possible to predict effects of humidity on carbon deposition, or extent of improvement of startability by increased humidity. A suggestion is made that ratings of test fuels should be expressed relative to a reference fuel tested under same humidity conditions. Seven literature references are given. U. M.

1283. Problems of combustion : liquid-propellant rocket motors. R. B. Canright. *Chem. Engng Prog.*, May 1950, **46** (5), 228–32.—The liquid-propellant rocket motor, its functions, and components are briefly described; rocket performance and design parameters are defined. The chemical reactions in the rocket are discussed, and the influence of injector, chamber, and nozzle in combustion considered, together with the use of non-carbonaceous fuels. J. G. H.

Lubricants

1284. Plant surveys and the lubrication engineer. E. R. Redgrove. *Scientific Lubrication*, Aug. 1950, **2** (8), 15–18.—The objects and routine of lubrication surveys in industrial plants are detailed, and the functions and training of the lubrication engineer considered. The lubrication requirements of I.C. engines and the properties of the oils used are enumerated. J. G. H.

1285. Stationary oil engine lubrication problems. E. B. Rawlins. *Scientific Lubrication*, Jan. 1951, **3** (1), 22.—Oil oxidation, types of deposits, operating requirements of detergent oils, oil changes, and reclaiming methods are briefly discussed. J. G. H.

1286. Air Force looks at synthetic lubricants. B. Rubin and E. M. Glass. *S.A.E. Trans.*, April 1950, **4** (2), 287–96.—Limitations in the performance of petroleum lubricants at extremely high and low temp leading to an interest in synthetic lubricants are enumerated, and the classes of material in the latter class are indicated. The composition and properties of diesters and their performance in greases and aircraft engine oils are discussed. The possibilities of synthetics as hydraulic fluids are touched upon, and problems encountered in the use of synthetics considered. J. G. H.

1287. Aircraft lubrication. 1—Petrol engines. K. C. Hunt. *Scientific Lubrication*, Sept. 1950, **2** (9), 15–20.—The high cost of aircraft development rendering necessary Government assistance has led to the formulation and wide acceptance of Government specifications for aircraft fuels, lubricating oils, and greases. The general lubrication requirements of the aircraft power-plant are outlined with notes on heavy duty oils, bearing and gear lubrication, oil cooling, foaming, cold starting, and petrol dilution. The Worth dilution system is described in some detail, and the formation of deposits, oil-drain periods, and the reclamation of used oils are discussed. The English and American Government specifications for piston-engine lubricants are outlined, and the desirability of retaining engine test requirements in such specifications is stressed. J. G. H.

1288. Aircraft lubrication. 2—Gas turbine engines. K. C. Hunt. *Scientific Lubrication*, Nov. 1950, **2** (11), 15–19.—The basic principles of the gas-turbine engine are briefly summarized. The special requirements for bearing lubrication are outlined, and the lubrication system of the Rolls Royce RB 37 Series V engine is described and

illustrated in some detail. Oil cooling, cold starting, and oil life are touched upon; the development of a specification for turbine lubricants is discussed, and characteristics indicated for a suggested specification. J. G. H.

1289. High-altitude aircraft oil systems. F. E. Carroll. *S.A.E. Trans.*, Oct. 1950, **4** (4), 519–29.—Difficulties experienced with aircraft oil systems at high altitudes are remarked and attributed to inefficient oil-pumps. Typical aircraft oil systems are reviewed, and re-designed systems discussed in considerable detail. Results of investigations at U.S. Army Material Command are summarized, and it is suggested that a realistic inlet condition to which aircraft-engine pressure oil-pumps should be designed is an inlet pressure of 2 inches of Hg absolute with 10% (by volume) of entrained air, also that the incorporation of the entire oil system in the engine is highly desirable. J. G. H.

1290. New S.A.E. classification includes 5W and 10W winter grades. Anon. *Scientific Lubrication*, Dec. 1950, **2** (12), 10.—Details of the new and former grades of S.A.E. crankcase oils. J. G. H.

1291. Synthetic lubricating oils—symposium. Various authors. *Industr. Engng Chem.*, 1950, **42** (12), 2414–68.—(*117th Mtg Divn of Pet. Chem., Amer. Chem. Soc., Houston, Mar.* 1950.)—Following are reviewed: relation between structure and physical properties, selection of lubricants for specific applications, German synthetic lubricants, polyalkylene glycol synthetic oils, polymeric additives for ester lubricants, non cat polymerization of olefins to lub. oils, boundary lubricating–flow characteristics of organopolysiloxanes, thermal and oxidation stability of polymethylphenylsiloxanes. R. G. T.

1292. Re-refining of used mineral oils by treatment with activated clay and heat. G. O. Ebrey. *Lubr. Engng*, Dec. 1950, **6** (6), 267–71.—The general technical principles involved in the re-refining of used mineral oils are summarized, and suitable applications indicated. Available re-refining installations are described, impurities present and methods used for their removal tabulated, and results of the reclamation of aircraft and railroad diesel lubricants and transformer oils presented together with cost data. J. G. H.

1293. Performance of high V.I. motor oils. C. L. Fleming, B. W. Geddes, N. V. Hakala, and C. A. Weisel. *S.A.E. Trans.*, July 1950, **4** (3), 410–21.—While V.I. additives have been in use for a considerable period, there has been considerable controversy on their effect on performance characteristics. The present paper provides additional data developed over a period of years on the effect of V.I. improvers on the cold-starting and consumption properties of motor oils. From the material presented it is concluded: that starting depends in part on visc of crankcase oil at starting temp, with low-visc oils giving better starting; low-temp starting properties of high-V.I. oils containing certain V.I. improvers are identical with those of straight mineral oils having the same visc at low temp; oil consumption depends in part on the high-temp visc of the crankcase oil, with higher visc oils giving less consumption; oil consumption properties of high-V.I. oils containing V.I. improvers are identical with those of straight mineral oils having the same visc at 300° F; high-V.I. motor oils offer the readiest means of combining good low-temp starting characteristics and low-oil-consumption properties in a single crankcase lubricant. The general tenor of the discussion indicated the need for more data to prove the value of V.I. improvers. J. G. H.

1294. Compressor lubrication. K. L. Hollister. *A.S.T.M. Bull.*, Dec. 1950 (170), 35–7.—A summary of a study of compressor lubrication, particularly from the standpoint of evaluating the newer type oils made by the Texas Oil Co. The procedure adopted was first to determine the properties of the various oils, second the requirements of different type compressors were examined, and from the data so obtained the best oil for each type compressor was selected.

As a basis for the investigation five commercial oils, all having a visc of approx 300 S.S.U. at 100° F were employed. These five were: (1) a straight naphthene oil; (2) the same inhibited against rust and oxidation; (3) the same naphthene compounded with 3% fatty oil; (4) a detergent heavy-duty oil; (5) a straight paraffin-

base oil. Specific requirements for conventional air-compressors, high-pressure air-compressors, diesel engines, refrigeration equipment, centrifugal blowers, and vacuum pumps are discussed in detail. J. G. H.

1295. D.E.U.A. report on heavy oil engine costs 1948/49. W. A. Tookey. *Gas Oil Pwr*, 1951, **46**, 7, 13.—An appraisal of the Diesel Engine Users Association report on engines at sixty-eight stations.

Various alterations in the scope of the tables which comprise the report are suggested. In particular, the lub. oil consumption should be reported in terms of cyl-hr per gal, since only on this basis can comparisons be made. (See also Abs. No. 1719, 1950. N.B. Reference in Abs. No. 1719, 1950 should be *Gas Oil Pwr*, 1950, **45**, 34, not 84 as originally given.) H. C. E.

1296. Lubrication in textile mills. F. N. McLaren. *Scientific Lubrication*, Dec. 1950, **2** (12), 20–2.—Recent American developments in textile lubrication are described, and non-staining oils, adhesive lubricants, ring-spindle oils, sludge formation, carding-machine box lubrication, and textile greases are discussed. J. G. H.

1297. Bearing materials, lubrication and oil grooves. H. Warburton. *Scientific Lubrication*, Aug. 1950, **2** (8), 22–3, 26.—The causes of bearing failure normally encountered are discussed with relation to lubrication. The special properties of low-melting-point alloys and carbon as bearing materials are outlined, together with the use of solid lubricants and colloidal graphite. The function of oil grooves in bearings is considered, and the relation between the grooving and the speed of the driven mechanism is indicated. J. G. H.

1298. Investigation of bearing materials under various degrees of lubrication in the low-speed range. L. A. Nowell. *A.S.T.M. Bull.*, Sept. 1950 (168), 47–53.—The first progress report of an investigation to measure the differences in several bearing materials under varying conditions of lubrication. Preliminary investigations here reported were made to adapt an Amsler wear-testing machine to this purpose. Control experiments presented herein were conducted on 30° and 60° steel-backed, Navy Grade 2 tin-base babbit bearings operating on a 2-inch dia journal with diametrical clearances varying from 0 to 0·004 inch. Navy symbol 2190-T oil was used. Range of speeds covered was from 25 to 350 r.p.m., and loads from 40 to 900 inches. Measurements were made of friction and of oil and bearing temp with observations on the electrical properties of the oil film. Results obtained indicate that the Amsler machine is adaptable to the testing of a variety of journal and bearing materials, including plastics, and that tests can be satisfactorily conducted with various lubricants, corrosive media, or abrasive particles. J. G. H.

1299. Oil holes and grooves in plain journal bearings. Anon. *Scientific Lubrication*, Sept. 1950, **2** (9), 10–13.—The work of McKee and White at the National Bureau of Standards on the comparative performance of plain journal bearings with various arrangements of oil holes and grooves in a four-bearing friction machine with forced-feed lubrication is summarized. The friction-testing machine used is described, and the various feed methods used are enumerated. The results obtained are tabulated, presenting friction ratings and load-carrying capacity ratings for each of the feed methods, and their significance is discussed. J. G. H.

1300. Note on the low pressure regions occurring in the hydrodynamic lubricating films of journal bearings. J. A. Cole. *Scientific Lubrication*, Jan. 1951, **3** (1), 10–13.—A survey undertaken by the Lubrication Division of the Mechanical Engineering Research Organization of D.S.I.R. of the present state of knowledge of the sub-atmosphere pressures which can arise on portions of the lubricating films of journal bearings and which are also predicted in the mathematical analysis of hydrodynamic lubrication. The question as to whether erosion in bearings is attributable to film cavitation or to the effect of high pressures is posed, and suggestions are presented for its solution. J. G. H.

1301. Load, speed and operating temperature of roll neck bearings. J. H. Hitchcock. *Lubr. Engng*, Dec. 1950, **6** (6), 252–5.—Results are reported of tests made to measure the load, speed, and operating temp of oil-lubricated sleeve-type bearings in the roll

necks of rolling mills in a variety of installations. Loads applied to the bearings were measured with gauge blocks equipped with resistance strain gauges, and temp by thermocouples located within the bearing metal close to the bearing surface. Results show the anticipated rise of temp with increasing load and speed, and in a few cases suggest a reasonable correlation of temperature with load and speed. It was found, however, that the operating temp varies considerably in different installations operating at equal load and speed, and can be changed appreciably in a single installations by changing visc or rate of flow of lubricant. This emphasizes the fact that operating temp depends on many factors and discourages determination of safe operating conditions in terms of load and speed alone. J. G. H.

1302. Friction, lubrication, wear. Review of papers, 1944–48. R. Kobitzsch. *Erdöl u. Kohle*, 1951, **4**, 9–17.—A literature survey divided into the following sections: friction; surface coatings to diminish friction and wear; lubrication; bearing problems; wear. Seventy-two references, mainly to German publications. V. B.

1303. Fundamental conclusions arising from the contact-hydrodynamic theory of lubrication. A. I. Petrusevich. *Izvest. Akad. Nauk S.S.S.R., Otdel. Tekh. Nauk*, 1951, 209–23.—New types of machines with high contact pressures, *e.g.*, gear trains, require the development of a new theory of lubrication in which effect of contact deformation is taken into account. Method of measuring such deformation at a plane surface has been developed. Examination of conditions for an oscillating or oscillating and sliding cyl, without taking deformation into account, shows that the hydrodynamic theory cannot be relied upon at pressures >1500 to 3000 kg/cm². Such a theory yields a thickness for the oil film which is less by a factor of 10 to 100 than that yielded by the new theory. Various aspects of the latter are discussed, *e.g.*, effect of surface irregularities, friction and wear, seizure. V. B.

1304. Self-lubricating carbon components. A. E. Williams. *Scientific Lubrication*, Nov. 1950, **2** (11), 10–13.—Details are presented of the application of "Delanium" and "Morganite" carbons in the construction of carbon bearings and piston-rings for compressors. The special properties of carbon in this direction are discussed, together with optimum operating conditions. J. G. H.

1305. Some uses for and properties of E.P. greases. A. E. Williams. *Scientific Lubrication*, Aug. 1950, **2** (8), 25–6.—The special properties of E.P. greases as applied to the lubrication of hypoid gears are noted, and the importance of consistency stability over a wide temp range is emphasized. The use of additives to this end is remarked, and the functions of sulphur and halogen compounds are discussed in some detail. J. G. H.

1306. Relation between pumpability and viscosity of lubricating greases. J. W. Amner, J. F. T. Blott, and S. Dawtrey. *Institute Spokesman*, Nov. 1950, **14** (8), 7–17.—The essential requirements for the prediction of flow in non-Newtonian systems are discussed, and details are presented of the method of measuring visc characteristics by means of the "Shell" plunger viscometer. The visc characteristics of various types of grease as measured with the Shell viscometer are detailed, together with their temp susceptibilities over the range of 0° to 20° C and 20° to 40° C. Experimental details are presented which confirm the validity of applying visc data to the flow of grease in pipes; the effect of the type of grease on pumpability is discussed, and applications of the foregoing data to practical flow problems are outlined. J. G. H.

1307. Manufacture of lubricating oils. C. M. Larson. *Lubr. Engng*, Dec. 1950, **6** (6), 263–6.—The composition of crude oils used in the manufacture of lubricants is briefly summarized. Distillation, dewaxing, chemical methods of refining, filtration, and blending are discussed, and the properties of lubricating oils made from different crudes by the various refining processes are tabulated. J. G. H.

1308. Separation of oil from exhaust steam and boiler feed water. Anon. *Scientific Lubrication*, Dec. 1950, **2** (12), 16–19.—The lubrication of steam-engine cylinders by atomizing the lubricant and injecting into the steam flow is noted, and the difficulties encountered by the presence of oil in exhaust steam are summarized with special

consideration of the use of compounded oils. Exhaust-steam separators, feed-water, de-oilers, and electrical de-oiling plant are described in some detail. J. G. H.

1309. Reclaiming cutting oils—prevention of dermatitis. H. M. Harman. *Scientific Lubrication*, Nov. 1950, **2** (11), 23–4.—Equipment and procedure for the reclamation of straight and soluble cutting oils are described, and precautions to be observed by operators for the prevention of dermatitis are indicated, together with procedure for sterilizing the solutions. J. G. H.

1310. Synthetic lubricants. W. Davey. *Scientific Lubrication*, June 1950, **2** (6), 10–13.—Recent developments in lubrication research are remarked, and the production of synthetic hydrocarbon oils by the polymerization of Fischer–Tropsch products is described with notes on the oxidation and heat stability of the lubricants so produced. The use of esters and their application to instrument lubrication is discussed, together with polyglycols of the "Ucon" type and the production and physical properties of silicones. J. G. H.

1311. Solubility and swelling of alkali soaps in organic solvents. A Bondi. *J. Coll. Sci.*, 1950, **5**, 458–70.—The behaviour of crystalline sodium salts of carboxylic acids in hydroxylic and hydrocarbon solvents has been observed under a microscope fitted with Nicol prisms and a hot stage. Swelling data are expressed as the ratio of crystal area at the observation temp to that at room temp.

Sodium stearate dissolves but does not swell in hydroxylic solvents above 80° C. It swells little in saturated hydrocarbons, but considerably in aromatic hydrocarbons. The degree of swelling at a given temp in 1-1-diphenylethane increases from sodium laurate to stearate, decreases as double bonds and OH groups are introduced into the radical, and is smaller for Li and K stearates than for Na.

The swelling process is discussed for the solvent 1-1-diphenylethane at 140° C. If the degree of swelling is plotted against the sum of the heats of transition to 140° C all the soaps lie on a smooth curve. Li 12-hydroxystearate neither swells nor shows any phase transitions below 165° C. It is concluded that swelling is due to the ingress of solvent after thermal loosening of the crystal lattice. H. C. E.

Bitumen, Asphalt, and Tar

1312. Twenty to thirty years' weathering of asphalt shingles made with unfilled coatings. G. L. Oliensis. *A.S.T.M. Bull.*, Apr. 1950 (164), 59–66.—While laboratory and weatherometer tests on asphalt coatings have consistently pointed to the greater probable durability of the filled over the unfilled types, in 1946 it was revealed that 10-year exposure tests on large panels of coating on saturated felt had failed to bear out this trend. The present paper presents additional evidence of a number of asphalt shingle roofs made with unfilled coating that have successfully weathered twenty to thirty years' experience, and suggests a reconsideration of roofing specifications. J. G. H.

Derived Chemical Products

1313. Amyl compounds from pentane. R. L. Kenyon, G. C. Inskeep, L. Gillette, and J. F. Price. *Industr. Engng Chem.*, 1950, **42** (12), 2388–401.—Pentanes are raw material for many amyl compounds. Vapour-phase chlorination is accepted as most conducive to high yields of primary chlorides. Theoretical principles are given. The Wyandotte plant at Sharples is described at length, with flow sheets for production of amyl alcohols, amyl acetate, amyl phenols, amyl naphthalenes, and amyl mercaptan. Various uses for all these products are listed, and the process economics and prospects are discussed. R. G. T.

1314. The manufacture of furnace carbon black from liquid hydrocarbons at Ellesmere Port. L. W. Cabot. J. W. Edminster, and C. A. Stokes. *J. Inst. Petrol.*, 1950, **36**, 707–18.—The production of carbon black in Great Britain technically and economically became possible only after the development of a new process using liquid hydrocarbons rather than natural gas as a raw material. The nature of carbon black and details of

the process and equipment used for its manufacture are described, with particular reference to the plant constructed at Ellesmere Port. A. R. W. B.

1315. Detergents for printers type. P. S. Smith. *Soap*, Dec. 1950, **26** (12), 44.—Printers have been aware for many years that the cleaning of type by hydrocarbon or other organic solvents, or by soap and lye solutions, is not satisfactory. These agents do not remove completely all traces of foreign matter which can affect the quality of proofs and cause damage to the type.

The properties of a satisfactory cleaning agent for this purpose can be summarized as follows: 1. The detergent must dissolve freely in water of any degree of hardness to give a clear, chemically neutral, solution capable of effecting substantial reductions in surface tension and interfacial tension. 2. The aqueous solution must not be coloured. 3. It must not hydrolyse in water, and must be stable over a wide pH range. 4. Low concentrations, such as 2 to 3 oz/gal, of water must be effective. 5. It must be non-volatile, non-toxic, and non-inflammable. 6. After cleaning, the type must be left dust-free and polished.

The sodium salts of higher alkyl sulphates have been found to meet these requirements satisfactorily. O. M.

1316. High viscosity detergent solutions. H. L. Sanders and E. A. Knaggs. *Soap*, Feb. 1951, **27** (2), 41.—It is highly desirable in many applications, such as liquid cleaners, shampoo concentrates, etc., that the detergent solution should have a high visc. The general approach to this problem has been the addition of thickeners, like carboxymethyl cellulose, which have no detergent power and quite often impart storage instability to the solution and promote mould-growth in hot weather.

The effect of addition of highly viscous detergents as thickeners has now been investigated, and it has been shown than an alkylolamide will increase the visc of solutions of anionic detergents such as alkyl aryl sulphonate considerably without conferring non-Newtonian characteristics on the resulting mixture. Further, addition of inorganic salts to such mixtures enhances the increase in visc. O. M.

1317. Detergents for mechanical dishwashing. C. A. Tyler. *Soap*, Dec., 1950, **26** (12), 37.—Detergents for mechanical dish-washing must be efficient and quick-acting and, from this point of view, alkaline salts are quite satisfactory. Such salts are, however, not the most efficient, and newer formulations are based on synthetic detergents. Soap, since it is affected too strongly by hard water and also foams is not used. The concentration of some detergents, such as alkyl aryl sulphonates, must be kept low, since they promote foam and, therefore, relatively small quantities of these are "built" with sulphates or phosphates for dish-washing. However, non-ionic detergents do not promote foam, and can, therefore, be used, unbuilt, in much higher concentrations. Poly-phosphates show extraordinary power in removing oily films from surfaces. They are not used alone, because not only has the dish-washing detergent to remove oily films from dishes but it must also prevent the soil from being redeposited thereon. The dispersing action required to achieve this object is supplied by the synthetic detergent, which also, of course, will displace oily films; in dish-washing high temperatures are desirable not only for efficiency but also as a precaution against the breeding of bacteria on the dishes. For this latter purpose, sanitizing rinses, containing quaternary ammonium compounds, are often used.

The article ends with some interesting information on detergent compositions formulated for specific purposes. O. M.

1318. Molecular interaction and its relation to formation of sodium dodecylsulphate/cetyltrimethylammonium bromide complex. R. Matalon, M. R. J. Salton, and M. Cohen. *Nature*, 1951, **167**, 241.—Precipitation of anionic by cationic detergents in equimolar amounts forms the basis of a method for their determination, but this precipitation is inhibited by the presence of polar compounds such as long-chain alcohols. Octyl or nonyl alcohols in equimolar ratio will inhibit the formation of the anion/cation complex. It is deduced that the alcohol/sodium dodecylsulphate complex is competing with the sodium dodecylsulphate/cetyltrimethylammonium bromide complex, and that as a result the anionic detergent has lost certain of its properties. H. C. E.

1319. High-frequency conductivity of paraffin-chain salts. R. Scott and T. R. Bolam. *Nature*, 1951, **167**, 195.—Measurements have been made of the conductivity at frequencies of 25 and 70 Mc/sec of sodium dodecylsulphate at concentrations up to 0·05 molar. Results are given in the form of "high-frequency effect" $F = 100\,\frac{\Lambda_\omega - \Lambda_0}{\Lambda_0}$, where Λ_0 is the equivalent conductivity at 1 Mc/sec and Λ_ω is the equivalent conductivity at 1 Mc/sec of a KCl solution having the same resistance at high frequency as the solution of dodecylsulphate.

A plot of F *versus* concentration gives a max at 0·02 molar at 25 Mc/sec, and an S-shaped curve at 70 Mc/sec. These results do not agree with earlier results, and the reasons for the discrepancy are discussed. The present results indicate that the "relaxation effect" has abnormally large values in micellar solutions of paraffin-chain salts. H. C. E.

Miscellaneous Products

1320. Petroleum products for the rubber industry. P. G. Croft-White and E. W. J. Beaven. *India-Rubber J.*, 1950, **119** (20), 776.—The magnitude of refinery operations in the petroleum industry is discussed, and the 1944 figures quoted show that the production of synthetic materials (as distinct from fuels and lubricants, etc.) represents a very small, but very important, part of the whole. An outline is given of the processes involved in refining crude oil. Various products of interest to the rubber industry are referred to in more detail. These include carbon black, aromatic petroleum softeners, mineral rubber, paraffin wax, naphthenic acids, and rubber solvents. The production of various types of synthetic rubber from petroleum raw materials is outlined, and a survey is given of some of the materials available or potentially available from petroleum sources, *e.g.*, ethyl alcohol, glycerol, aromatics, sulphur, carbon disulphide, ester plasticizers for nitrile rubbers, polyvinyl chloride, hydrogen cyanide, and amines. It is concluded that the petroleum chemicals industry has made considerable contributions to the rubber and plastics industries, and to synthetic detergents, etc., and that future applications will be still wider. C. N. T.

1321. Further studies on aerosol formulations with Lethane and other toxicants. F. B. Maughan, F. M. Mizell, and J. P. Nichols. *Soap*, Feb. 1951, **27** (2), 125.—Describes the latest data on knock-down and kill properties of aerosol formulations containing D.D.T., pyrethrins, allethrin, Lethane 384, and synergist MGK-264. The investigations have shown that combinations of allethrin, synergist, and Lethane 384 yield highly satisfactory aerosol formulations with or without pyrethrins. O. M.

Corrosion

1322. Planning corrosion studies. J. A. Kornfeld. *Oil Gas J.*, 22.2.51, **49** (42), 186.—Co-ordination of field engineering with laboratory studies, cost economics, and continuous progress control are features of approach to corrosion problems made by Atlantic Refining Co. Dallas.

A chart gives procedure for handling a corrosion study. G. A. C.

1323. What the soil does to pipe. M. E. Parker. *Oil Gas J.*, 8.2.51, **49** (40), 111.—A review of causes of corrosion of buried pipes; it is shown that besides different metals, different soils, and different aeration, almost any difference in conditions at two points on surface may create a corroding cell.

New pipe buried and connected with the oil is anodic to the old pipe, and thus takes brunt of corrosion. G. A. C.

1324. Pipe-to-soil potentials as an indication of corrosion. M. E. Parker. *Oil Gas J.*, 1.3.51, **49** (43), 65.—Potential drop in soil associated with flow of current leaving buried pipe is measured at different points, and thus corroding areas detected. Readings are taken at surface of the ground. Method is not applicable to bare pipe. G. A. C.

1325. How to locate "hot spots." M. E. Parker. *Oil Gas J.*, 15.2.51, **49** (41), 116.—Hot-spot protection of bare pipeline may prevent up to 90% of leaks at a cost of 15% of that of complete protection of line. A method to locate hot spots before leaks occur, based on measurement of electrical resistivity of soil, is described. G. A. C.

1326. Basic principles of cathodic protection. M. E. Parker. *Oil Gas J.*, 22.2.51, **49** (42), 194.—Protection systems are outlined, and four diagrams show application to specific cases of cathodic protection. Source of energy may vary from a small rod of zinc to a generator. G. A. C.

1327. Criteria for cathodic protection. Anon. *World Oil*, July 1950, **131** (1), 177–8.—Of the several recognized criteria for complete corrosion protection, that based on current density is in common use for estimating the current requirements prior to application. Indicated current values required to protect bare steel in natural soils and waters have been found to vary from 0·5 to 5 mA/sq. ft., and for coated steel from 0·01 to 0·5 mA. After installation a copper/copper sulphate half-cell can be used as a reference. It has been found that if the potential of the buried structure referred to the half-cell is −0·85 V then sufficient current is flowing. The cost of reconditioning 1 mile of bare 8-inch line will be approx $10,000. Cathodic protection, using magnesium blocks large enough to last the period, can be obtained for ten years for approx $1785. A. H.

1328. A bibliography on cathodic protection. F. A. Rohrman. *World Oil*, July 1950, **131** (1), 179–90.—436 references are given, and are claimed to include every paper pertinent to the subject from 1842 to the latest available sources of 1949. The material is arranged by the year, and then alphabetically by authors under each year. Each inclusion is preceded by a letter which shows the main type of protection or anode used in the discussion. A. H.

1329. Techniques in determining and preventing electrolytic corrosion. R. L. White. *Producers' Monthly*, Aug. 1949, **13** (10), 25.—Two methods are described for determining the so-called " anodic areas " where pipeline corrosion occurs, and a method of corrosion prevention using ribbon-type magnesium anodes is briefly described. R. B. S.

1330. Stabilization of cooling tower water. H. Shields and L. V. Sorg. *Oil Gas J.*, 1.3.51, **49** (43), 52.—A process is described which clarifies water from Missouri River used at Sugar Creek refinery of Standard Oil Co. to turbidity of 10 p.p.m. or less, and chemically stabilizes the water so that scale deposition or corrosive attack will not occur in Admiralty and iron tubes of coolers served by the treated water.

Clarification plant consists of a primary-sedimentation chamber and two horizontal-type precipitators, with pumping, mixing, and chemical addition facilities.

Clear water at outlet is adjusted for pH, and a stabilizing agent consisting of a blend of polyphosphates, soda ash, and ligum sulphonate is added.

Tables show character of raw and treated water, and results of examinations of test specimens.

Three figures illustrate the article. G. A. C.

1331. Minimizing red water troubles. L. C. Case. *World Oil*, July 1950, **131** (1), 152–4.—Water, burdened with iron, is commonly known as " red water," since accumulations of iron deposited in pipes are sometimes stirred up and give a red coloration. This is objectionable in drinking waters, and can produce clogging when the water is used for secondary recovery. It can be removed by chemical treatment, but this is often difficult at small field stations. Simple aeration and subsequent filtration has been found to be successful. The reaction follows the equation

$$4Fe(HCO_3)_2 + O_2 + H_2O = 4Fe(OH_3) + 8CO_2$$

The conversion to insoluble ferric hydrate is hastened by the presence of hydroxyl ions. The small pressure filter is easily cleaned by backwashing. Equipment cost is low, and the aeration has been shown to inhibit anaerobic bacteria of the iron-consuming type. It is strongly indicated that the oxygen added to the water during

aeration does not materially increase the rate of corrosion attack of uncoated steel tanks, etc., and it is believed that the change from high CO_2 to high O_2 content has actually lowered corrosion rate. A. H.

Engines and Automotive Equipment

1332. Power developments over twenty years. Anon. *Aeroplane*, 2.3.51, **80** (2067), 260.—The James Clayton Lecture on "The Aviation Engine" given before the Inst. Mech. Engrs. in London, 16.2.51, by Air-Commodore F. R. Banks, is summarized. The first part of lecture, dealing with the piston engine, outlined developments by Bristol, Rolls-Royce, and Napier, and gave details of their various engines. Mention is made of other subjects dealt with in the lecture, such as mechanically driven superchargers, variable pitch airscrews, the exhaust turbo-blower, fuel injection, relative merits of air and liquid cooling, sleeve- and poppet-valve engines, etc. Second part of lecture dealt with gas-turbines. Relative applications of the three types, turbo-jet, ducted-fan, and propellor-turbine were discussed, and merits of axial and centrifugal compressors compared. Future developments were reviewed, and informative material presented regarding relative specific thrusts. On question of fuel the lecturer considered that for next five years there should be sufficient kerosine to meet relatively small demands of turbine engined aircraft. If there were to be a world war during next five years, however, the aviation gas-turbine would be committed to a fuel having a predominance of hydrocarbons in gasoline boiling range, resulting in a loss of operating range of anything up to 10% for a given aircraft tankage. Servicing and maintenance of turbo-jets and piston engines were compared, and future uses of both types outlined. U. M.

1333. M.I.R.A. Annual Report. Anon. *Gas Oil Pwr*, 1951, **46**, 12.—Among the research work undertaken by the Motor Industry Research Association during the period July 1949 to June 1950 are the following: Irreproducibility of behaviour of piston-rings, in particular that of intermittent rotation; fuel sprays for I.C. engines, comprising (*a*) atomization of sprays, (*b*) flow in spray atomizers, (*c*) engine tests with petrol injection; lub. oils for high-speed C.I. engines. This latter work aims at establishing a 50-hr bench test, using a British engine which will differentiate between a H.D. and a plain lub. oil. The engine runs on fuel containing 0·2% sulphur, and the lubricant is judged on the basis of (*a*) increase of blow-by rate during the test, and (*b*) number of rings stuck at the end of the test. H. C. E.

1334. Fuel injection. A. E. W. Austen and B. E. Goodridge. *Auto Engr.*, Mar. 1951, **41** (538), 109.—The paper describes work carried out on the evaluation of fuel-filter performance and on the influence of abrasive-particle size on the wear of fuel-injection equipment. Gauze, cloth, and felt filters common in Great Britain seldom result in seizure and blockage, but they do not eliminate abrasive wear. The method of carrying out the investigation was to determine the wear produced by various sizes of abrasive particles, and the relative merits of various filters were determined by measuring the particle transmission for various particle sizes in the damaging range. In addition to preventing wear a filter must be capable of filtering a large volume of contaminated fuel without choking, and a means of evaluating the choking properties of filters has been devised. Alumina was selected as a suitable material for the particles, and sizes down to 2μ were obtained by air elutriation or centrifuging in water. The tests carried out to show the wear caused by various sizes of abrasive particles are described and the results tabulated. The filter trials are also described, and an attempt is made to devise a hypothesis of the mechanism of the choking of filters by wax sludge and to relate the wax-choking properties to other more easily measured quantities to provide a basis for the comparison of materials of different particle-transmission properties and thickness. It is shown that for some services improved filtration is necessary. Paper transmits fewer particles than cloth or felt but chokes more readily, necessitating the use of a large filter area. However, with correct design and using paper of suitable quality paper filters appear to be practicable, giving a greatly improved pump-element life with adequate filter-element life.

A. S.

1335. Speed control and synchronization of multi-unit internal-combustion-engine plants. H. C. Givens. *Oil Gas J.*, 1.3.51, **49** (43), 69.—Systems to control two or more I.C. engines running in parallel are described, and advantages, disadvantages, and limitations discussed. Simplest method is to instal a pneumatically set flow controller with automatic reset on discharge from each compressor or pump, output from pressure-control instrument sets all controllers.

Seven figures illustrate the article. G. A. C.

1336. Mufflers—their function and design—in stationary internal-combustion engines. M. P. Siroff. *Oil Gas J.*, 1.3.51, **49** (43), 73.—Design of equipment to muffle exhaust noise of I.C. engines is discussed, and types examined.

Mufflers must silence, eliminate pulsative waves, meet specified minimum pressure drop, and discharge gases at a safe elevation.

Mufflers can be divided into two classes, air-cooled and non-air-cooled. Air-cooled type used in petroleum industry, the non-air-cooled mufflers are designed for engine-rooms where ventilation is not an important consideration. G. A. C.

1337. Chrome plating of piston rings. J. L. Hepworth. *Scientific Lubrication*, Dec. 1950, **2** (12), 13–15.—The properties of chromium-plated liners are outlined, and the development, advantages, and production of chromium-plated rings discussed. Performance figures of chromium-plated rings over a period of two years are presented. J. G. H.

1338. Laboratory study of intake valve burning. C. L. Wolfe and R. S. Spindt. *A.S.T.M. Bull.*, Feb. 1950 (164), 43–7.—A progress report is presented on an investigation of the conditions under which intake-valve deposits and intake-valve burning might be anticipated in gasoline-powered vehicles. A two-cyl 90-degree V-type engine especially designed for research purposes was employed. Initial exploratory studies were carried out to find operating conditions which would burn intake valves, and the effects of altering mechanical and operating variables are discussed, including effect of fuel type, and of air–fuel mixture temp. J. G. H.

1339. Recent trends in engine valve design and maintenance. N. Hoertz and R. M. Rogers. *S.A.E. Trans.*, July 1950, **4** (3), 347–56.—A review of valve design covering materials, hard facing, sodium filling, and valve-rotating devices with the object of giving an insight into qualities and limitations in materials and design. Problems relating to springs, seats, guides, and tappet clearances are considered in so far as they relate to valve performance, together with valve sticking and burning. J. G. H.

1340. Crankcase explosions and their prevention. F. V. Cooke. *Scientific Lubrication*, Jan. 1951, **3** (1), 14–16.—Previous theories as to the causes of crankcase explosions are criticized, and it is claimed that these result from ignited mixtures of vapour and air that fill spaces between the droplets of oily mist in the crankcases. Crankcase ventilation, preventive measures, and the use of relief valves for this purpose are discussed. Details are presented of methods of valve testing. J. G. H.

1341. Cold starting aid for diesel engines. Anon. *Engineer*, 1951, **191**, 188.—A new cold-starting device for diesel engines is expected to be commercially available within a few months. It consists of a 7-cc capsule of fluid with high diethyl-ether content, fitted into charger which screws into inlet manifold. A very rich mixture is drawn into engine initially which fires immediately, then a weaker mixture which keeps engine running until combustion chamber is hot enough to run on normal fuel. Typical tests on five engines using cold-starting device showed reduction in starting time from 25 to 50 sec down to 2 to 4 sec, min starting temp being reduced from 10° to 20° F down to 0° to −20° F. A. C.

1342. C.A.V. cold starting device for diesel engines. Anon. *Mech. World*, **129** (3346), 207.—Experimental work has shown that diethyl ether introduced into the intake air provides the most effective aid to starting diesel engines. The C.A.V. cold-starting device supplies: (*a*) a rich ether–air mixture during the first stage of cranking, to obtain the first ignition; (*b*) a controlled rate of supply of ether after ignition has occurred to give a weak mixture to enable the engine to run and to heat the com-

bustion chamber quickly for running on normal fuel oil. The design described has few parts, no fine jets or holes, and is practically foolproof. The starting fluid is contained in a capsule of plastic material, and there is no loss by evaporation, and no fluid is wasted by spilling. The fluid contains a proportion of lubricant. The method of operation is described, and illustrations show the construction of the device. Results with five typical engines, including direct-injection and indirect types, showed that the starting time could in each case be reduced to a few seconds. A. S.

1343. Articulated diesel-electric locomotives for Egypt. Anon. *Gas Oil Pwr*, 1951, **46**, 4–6.—These locomotives are constructed as a part of units of five cars. The motive power is provided by two diesel engines of the English Electric SRKT type, each developing 400 b.h.p. at 750 r.p.m. These four-cyl four-stroke engines have cyl with bore and stroke of 10 and 12 inches respectively, and are fitted with exhaust-gas turbo-pressure chargers. They incorporate a positively driven balancing system which eliminates the vertical unbalanced secondary forces developed in all four-cylinder engines.

The generator, governor gear, and safety devices are briefly described.

The trains will seat 172 passengers, and in full running order each weighs 152 tons. The max starting effort and continuous tractive effort are 18,000 and 7250 lb (at 29·5 m.p.h.) respectively. The max designed speed is 75 m.p.h. H. C. E.

1344. Two new McLaren units. Anon. *Gas Oil Pwr*, 1951, **46**, 14.—The M8 type engine has 8 cyl each of bore 142 mm and stroke 200 mm, and develops 176 b.h.p. at 1000 r.p.m. on the 12-hr rating. Power can be increased intermittently to 220 b.h.p. at 1100 r.p.m. The cyl-head has two inlet valves with separate passages to create turbulence, and two exhaust valves with a common passage. The four-hole injector, positioned centrally between the valves, is cooled, and fuel is sprayed directly into the combustion chamber in the piston crown. This arrangement is said to improve thermal efficiency, with a saving of some 10% of fuel.

The Petter–Fielding type DH pumping set is a single-cyl horizontal engine with bore and stroke 142 and 200 mm. It develops 16 b.h.p. at 800 r.p.m. The Al-alloy piston has three compression and two scraper rings. The cyl-head carries one exhaust and one inlet valve, but otherwise resembles that of the M8 engine. Full-pressure lubrication is supplied to main and big-end bearings, gudgeon-pin, and governor gear. A V-rope drive transmits power to a centrifugal pump of capacity 800 g.p.m. against a 40-ft head. H. C. E.

1345. Auxiliary gas turbines for pneumatic power in aircraft applications. H. J. Wood and F. Dallenbach. *S.A.E. Trans.*, Apr. 1950, **4** (2), 196–216.—The problem of providing adequate auxiliary power for large aircraft is discussed, and the possibilities of gas-turbines as a means to this end are considered, using as alternatives a gas-turbine compressor and a gas-turbine power unit. Power demands likely to be encountered are enumerated, power sources and load analysis discussed, and the conclusion is reached that the pneumatic system represents a practical solution to the auxiliary power problem for large aircraft up to altitudes of 50,000 ft, if bleed air is taken from the main engines and combustion of fuel takes place to mix the bleed-air temp. J. G. H.

1346. Burners and combustion chambers for gas turbines. Anon. *Mech. World*, 9.3.51, **129** (3347), 217.—The effects on the burner and combustion chamber of grade of fuel consumed, atomization of the fuel, combustion air distribution, and airflow patterns are discussed from the point of view of the designer, using existing designs for illustration. A number of illustrations show the features of construction of burner types used in gas turbines including conventional air atomizers and swirling pressure jets ranging from the simplex to the more complicated wide-range types. The characteristics of these different types are described. As far as combustion chambers are concerned, by far the greater number which have seen continuous usage in recent years have been the small, all-metal aircraft type. In this country the design of industrial or marine chambers has moved in the direction of large single ones. In the case of aircraft with the axial compressor coming to the fore, a good deal of progress is being made with annular combustion chambers. With a view to the requirements of

long life and the burning of heavy fuel on the industrial side two types of combustion chamber are described. They are: (1) refractory lined in the primary zone only, and (2) a "louvred" wall design. The principle of the louvred wall is shown in simplified drawings. A. S.

1347. Practical conclusions on gas turbine spray nozzles. F. C. Mock and D. R. Ganger. *S.A.E. Trans.*, July 1950, **4** (3), 357–67.—Requirements in gas-turbine power-plant fuel-spray nozzles, as indicated by operating experience, include, as prime factors, a high degree of atomization and evenness of fuel distribution, particularly at low fuel rates. The significance of adequate distribution at low delivery range is stressed and the three stages of atomization are discussed. The limitations of simple swirl nozzle are enumerated and compared with the performance of duplex nozzles to the marked advantage of the latter, and alternative installations with duplex nozzles are described. J. G. H.

1348. Ruston gas turbine developments. Anon. *Gas Oil Pwr*, 1951, **46**, 17.—Various improvements of detail in the experimental 750-kW gas-turbine unit installed a year ago at Ruston & Hornsby's works at Lincoln have given greater efficiency. It is found that deposition of dirt on the blades of the thirteen-stage axial compressor causes only slight reduction in the efficiency of the compressor. The thermodynamic performance of the heat exchanger has been satisfactory.

The unit has now been operating for more than 1030 hr, and in a single test developed 900 kW when operated without the heat exchanger.

The use of peat as a gas-turbine fuel is now the subject of research, and it is expected that the unit will be able to operate on fuel containing up to 80% wt of water. H. C. E.

Safety Precautions

1349. Safeguarding plant from voltage reduction—III. Anon. *Mech. World*, 2.3.51, **129** (3346), 202.—In the case of D.C. motors there would be little difficulty in starting them on low voltage because the motor torque increases as the starting resistance is cut out until the motor starts to move. A series motor can therefore develop its normal starting torque on quite a low voltage. In the case of a shunt motor, however, an increased armature current will be required to develop a given torque on reduced voltage. In consequence, it may be necessary to use larger fuses or increase the setting of the over-current trip. In starting a differential compound motor on low voltage difficulty would probably be experienced if the series field windings were in circuit during starting. The remedy is to short-circuit the series field coils during starting. Fractional-horse-power motors seem particularly susceptible to low-voltage troubles, since the overload capacity is usually almost nil, the starting torque is often not very high, and these motors have little margin above the power requirements of the driven machine. Curves are supplied which show the characteristics of various types of single-phase motor on normal voltage and also on 90% of normal voltage. Methods of improving starting conditions are described. A. S.

1350. Safeguarding plant from voltage reduction—IV. Anon. *Mech. World*, 9.3.51, **129** (3347), 225.—A good measure of protection against overheating due to low voltage, and some protection against failure to start is afforded by over-current trips set to operate at about 25% above the rated current value, provided that the trips are in working order. Anything which prevents the starter mechanism from moving freely may also interfere with the protective gear. Possible troubles are rough or burnt contacts or welded contacts, stiff mechanism, excessive contact pressure, weak or broken return springs, strained contact mechanism, jamming of mechanical interlocks, grooves worn in hold-on catches, rusty or dirty catches. The characteristics of D.C. and A.C. electromagnets on low voltage are described. Control gear may have to carry increased running current when the voltage is low, and may also have to carry starting currents for longer periods than normal. To avoid dangerous overheating it is particularly important to keep such gear clean and well ventilated and to maintain the oil in oil-immersed gear at the correct level. A. S.

1351. Safety training by specific problems. Part 5. The driller's responsibility in accident prevention. J. I. Powell. *World Oil*, Aug. 1950, **131** (3), 122–30.—Out of 700 accidents examined, thirty were connected with draw-works practice, thirteen with rotary miscellaneous practices, and four with hoisting practice. A driller should realize the limitations of his crewmen and ensure that they do not take risks, especially when the driller's attention is otherwise occupied. Drillers received leg injuries through their feet slipping from pedals. It is recommended that pedals have raised edges. A fortunate escape from more serious injury occurred when a drill line ran off an ice-filled sheave and broke. When icing conditions are bad, scrapers should be fitted to sheaves. A. H.

MISCELLANEOUS

1352. Athabasca bituminous sands. K. Clark. *Fuel*, Mar. 1951, **30** (3), 49–53.—The geology and nature of the Athabasca bituminous sands are described, and the research work carried out on them is surveyed with respect to drilling and mapping, separation of the oil by (1) hot and (2) cold water, continuous retorting, and the hydrogenation of the separated viscous oil. The use of the tar sands for paving is outlined, and the four separation plants, all employing the hot-water method, are described. A technical and economic survey is given. The present view is that the development of the tar sands has been relegated to the indefinite future. A study now under way may show that economic considerations do not necessitate a long delay for commercial development. W. H. C.

1353. New technique taps Athabaska tar sands. K. A. Clark. *World Oil*, 1.2.51, **132** (2), 205.—A pilot plant operating at Bitumont, Alberta, during 1949 has recovered approx 90% of the oil from tar sands, as a wet product containing 4% mineral matter and 30% water. The oil was dehydrated by evaporation after cutting the crude with distillate. Although efficient oil extraction from the sands is technically possible, economic methods of large-scale development have not yet been found.

The limits of the Athabaska deposit are unknown; but there are at least 1500 sq. miles along the Athabaska River north of Fort McMurray. The sand is 100 to 200 ft thick, consisting of Lower Cretaceous quartz sand and clay. The oil is — 10°, containing approx 5% sulphur. Max oil content is 18% by weight, averaging 12 to 16%. Estimated reserves are 100 to 250 million brl.

Details of the process used to extract the oil from the sands are included.

C. A. F.

1354. Alberta's tar-sand deposits. Anon. *Times Rev. Ind.*, 1951, Mar., 66.—Tar-sand reserves contain min of 100,000 million brl. Two extraction methods have been proposed, one based on hot-water treatment and the other on heating sand to 500° C with air-blast through it, this causes distillation of oil and leaves as residue a coke-coated sand which can be used as fuel, thus making the process self-contained. Both methods may, at present crude prices, prove economical; in any case sands are of great value as potential strategic pet reserve. Map of sand area is given. V. B.

1355. Gaseous fuels and their significance in the future. F. H. Garner. *Advancement of Science*, Mar. 1951, **7** (28), 418–24.—A historical account is given of the coal-gas industry, the use of coal gas, production and uses of: producer gas, water gas, blast-furnace gas, sewage gas, synthesis gas, natural and refinery gases are outlined. The special advantages of gaseous fuels are discussed, and the efficiencies as compared with coal and electricity for domestic and industrial heating are described and discussed from the aspects of transport and peak loads. Methods for meeting the increased demand for gas are described. Underground gasification of coal is summarized. The advantages and possibilities of the gas-turbine are discussed. W. H. C.

1356. United Kingdon petroleum consumption. Anon. *Gas Oil Pwr*, 1951, **46**, 15.—Covering the three years 1938, 1948, 1949, this article includes three tables: (1) consumption of petroleum products (in terms of products); (2) analysis of deliveries

into consumption (in terms of uses within industry); (3) production of petroleum products ex imported and indigenous crude and process oils. H. C. E.

1357. Petroleum and European recovery. V. Smith. *J. Inst. Petrol.*, 1951, **37**, 2–15.—The indispensable contribution of the oil industry to the great post-war economic achievements of the countries of Western Europe is described, and the growing awareness in Europe of the value of oil as a source of energy is demonstrated. A. R. W. B.

1358. The development of Canada's petroleum industry. J. K. O'Sullivan. *I.P. Review*, 1951, **49**, 1.—The development of Canada's petroleum industry can be divided into three main periods. The first commenced about 1850, and saw the setting up of the early oil companies. First bitumen and later kerosine was the main product. There were many early obstacles to progress, chief among these being the shortage of equipment and intense American competition. The second phase opened at the beginning of the twentieth century and lasted until 1947. The motor car had opened up many new uses for petroleum products, and the quantity of material imported from the U.S. increased considerably. Restrictions upon export from the U.S. during the 1914–18 war caused the Canadian industry to make greater efforts. Refineries were built, and the industry expanded in many directions. The third period since 1947 has been characterized by big demands for new types of products. The discovery of new sources of oil has improved the situation, and great effort is being directed to oil prospecting. Increased production has been curtailed by difficulties of transport, but the use of the pipeline has been a tremendous asset, and great attention is paid to this mode of transport. R. H.

1359. Property in submarine sub-soil. J. P. Govare and J. Warot. *Rev. Inst. franç. Pétrole*, 1951, **6**, 83–8.—A discussion of the legal problems arising out of the exploitation of mineral deposits under the sea-bed and outside the traditional 3-mile limit. Claims outside such limit have been made by various countries, commencing with the (British) Cornwall Submarine Mines Act of 1858 and greatly increasing in number since 1945. Many nations lay claim to "continental shelf," frequently defined as the 200-m isobathe (600 m claimed by the U.S.A.) others (Peru, Chile) have claimed 200 miles. View of French branch of the International Law Association is that national authority should be extended to the 200-m isobathe or, when coast shelves rapidly, to 20 miles; special treaties will have to be made in cases such as the English Channel and North Sea, where several countries are contiguous to same shallow seas. Alternative views put before the International Law Association are summarized. V. B.

1360. Work of the eminent Soviet scientist S. S. Nametkin in the field of chemistry and petroleum technology. A. V. Topchiev, S. R. Sergienko, and P. I. Sanin. *Izvest. Akad. Nauk S.S.S.R., Otdel. Tekh. Nauk*, 1951, 3–21.—A scientific appreciation and assessment of the work, mainly in hydrocarbon and petroleum chemistry, of Sergei Semenovich Nametkin (1876–1950). V. B.

1361. Operational research. R. E. Strong. *I.P. Review*, 1951, **49**, 11.—Operational research is defined as "The study of executive affairs by the use of scientific method." It originated during the last war, and was applied with great success to military problems of various kinds. A similar technique had been developed in mass-production processes in the U.K. during earlier years. Operational research has been applied to steel rolling, to the cotton industry, and to many commercial problems. It can be applied successfully to problems only when: (1) there is some degree of repetition, (2) there are factual data available, (3) there are some facilities for controlled experiments. Operational research workers must have: (1) training in scientific method, (2) wide general and scientific interests. Great advantages can be obtained by the application of operational research, but it should be noted that very often the long-established method of doing any particular operation is not necessarily proved to be the best. Hence application of this principle does meet with opposition. R. H.

BOOK REVIEWS

Aspects of the Constitution of Mineral Oils. K. van Nes and H. A. van Westen. New York: Elsevier Publishing Co., 1951. Pp. xxiv + 484. $9.00. (London: Cleaver-Hume Press. 70*s*.)

The primary object of this addition to the well-known Elsevier publications is stated to be the introduction of a hitherto unpublished method of structural group analysis. The final achievement is a volume comprising a compact but comprehensive survey of the present state of knowledge concerning mineral oil constitution. The work of H. I. Waterman, J. C. Vlugter, and their associates in this field is outstanding, and this book, written by their colleagues at the Koninklijke/Shell Laboratory Amsterdam, is no exception.

The first two chapters deal with the classification of crudes according to type and the genesis of mineral oils. In Chapter III (pp. 67–241) the physical properties of hydrocarbons are surveyed and methods of separation reviewed, *i.e.*, distillation, solvent extraction, extractive crystallization, adsorption, and thermal diffusion. Available methods of characterization and identification are considered, and details given of known constituents of mineral oils. Chapter IV (pp. 242–399) embraces structural group analysis, and includes descriptions of the well-known methods of Waterman (" ring " analysis), Deanesly and Carleton, Lipkin *et al*, Kurtz and Ward, and many others. The new method, named the n-d-M method, is introduced, its development and testing described, and its accuracy, scope, and limitations discussed in relation to those of the older methods. Determinations of refractive index (n), density (d), and molecular weight (M) are required with respective accuracies, $\pm$ 0·0001 and better than 2 per cent of the value found. The results are expressed as percentage of carbon atoms in aromatic nuclear structure (per cent C_A), in naphthenic nuclear structure (per cent C_N), and in paraffinic structure (per cent C_P). The carbon in paraffinic structure includes the carbon of purely paraffinic molecules, as well as the carbon in alkyl groups which are combined with aromatic or naphthenic structures. The ring content is calculable as the mean number of aromatic rings R_A, and the mean number of naphthene rings R_N per molecule respectively. The correlation results given are encouraging, and it is refreshing to observe that for the first time, a published method of " ring analysis " takes into account the content of sulphur compounds, a factor which has been ignored so blatantly by previous workers.

Comparisons with available methods of structural group analysis are included, and variations in bases, procedure, and applicability discussed. Examples of actual analyses are correlated with physical properties such as viscosity, viscosity index, ignition characteristics, etc. The influence of group analysis on the study and control of refinery operations in the petroleum industry is discussed, and it is demonstrated how the selection of appropriate feedstocks for different processes can be materially assisted.

The mathematical derivation of the formulæ of the n-d-M method and the experimental details for the determination of density, refractive index, and molecular weight are given in appendixes, and appearing at the end of each chapter is a complete bibliography, which for the whole totals nearly 500 references.

This volume is a work which few petroleum technologists could read without acquiring valuable knowledge and techniques. H. C. R.

White Mineral Oil and Petrolatum. E. Meyer. New York: Chemical Publishing Co. Inc., 1950. Pp. 135 + vi. $4.75.

White mineral oils form a relatively neglected chapter in the literature of petroleum and, on receiving the work under consideration, the reviewer hoped that a comprehensive monograph on this subject was at last to hand. However, he must confess to a feeling of some disappointment. According to the statement on the jacket of the book " The ingredients and nature of crude oil, its refining by chemical treatment, the quality standards of white mineral oil and petrolatum and their manufacturing process are discussed *in detail* " (italics added). This is an over-statement; after dealing with the origin of petroleum, the chemical structure and classification of

crude oil and its production and transportation all in four pages, the author then devotes less than one page to the general principles of refining, two and a half pages to acid refining, half a page to adsorption refining of white oil, and a couple of pages to the manufacture of petrolatum.

As a guide to refiners it may thus be said that the value of the work, in so far as any information concerned with the production of the materials discussed is concerned, may be dismissed as negligible. When, however, we come to the chapter on applications of white mineral oil and petrolatum, which forms the bulk of the book (84 pages), there is given a useful account, arranged in alphabetical order from " Air Filters " to " Veterinary Preparations " of the numerous uses to which these specialized products can be put, including such varied utilizations as carbon-paper manufacture, leather processing, pea cleaning, quartz cutting, and tobacco processing.

The author is attached to the Department of Industrial Research of L. Sonneborn Sons, Inc., and thus obviously has had an extensive experience of the applications of white oils and petrolatums (the latter is the plural form favoured by author, but might " petrolata " not be more correct ?).

In each section a short explanation is given of the function performed by the product and, where necessary, of the main features of the manufacturing process in which it is applied. This is followed by a tabulated statement of the principal requirements which the oil should in each case meet and a quantitative expression of these requirements in terms of the standard tests such as viscosity, flash point, boiling point, colour, etc.

In many cases literature references (almost exclusively to U.S. sources) are quoted, but these are not by any means as extensive as would be desirable.

Some of the statements made in this chapter are, however, of doubtful reliability. Thus, when describing the use of white oil as an anti-foaming agent in the production of beet sugar, the author states : " Sugar beets, the primary source of American sugar . . ." Actually cane sugar forms by far the larger proportion of U.S. sugar consumption, beet sugar accounting for less than 25 per cent. Of interest, is a similar case of white oil as an anti-foaming agent, mentioned under the heading of penicillin manufacture.

In discussing the use of white oils in electrical equipment the author's advocacy of white oils in cables and transformers is unlikely to receive much support, and his recommendation of a Michie sludge test value of 0·02 to 0·03 per cent as desirable is many years out of date. Incidentally, Table II (p. 56), the property requirement chart for electrical oils, is not adequately titled, and from its location might be confused with the property requirements of oils for the food industry. Dealing with the use of white oils as upper-cylinder lubricants (surely a somewhat extravagant utilization ?) the author recommends that such lubricant be poured into the tank *before* the addition of the gasoline ; this hardly seems the best course to ensure adequate mixing. There is an evident misprint on p. 60, presumably the proportion of dye in upper-cylinder lubricant should be 0·5 per cent and not 5·5 per cent. In the recipe given on p. 66 for a fat-liquoring emulsion for leather treatment the " petrolatum sulfonate " mentioned should presumably read " petroleum sulfonate."

Surprisingly little space is devoted to the internal medicinal use of white oil, in view of the importance of this particular application, and no references are given to the considerable medical literature that has appeared, especially in recent years, on this aspect. It is interesting to note that the label that is mentioned as being generally used in the U.S.A. for medicinal oil clearly states that it should only be taken at bed-time, which is in accordance with recent recognized medical opinion on this subject. The author's inclusion of the cloud test as one of the requirements making white oil safe for internal use (p. 63) is certainly open to question, a cloud test may be æsthetically desirable, but, as the oil is utilized at body temperature (approximately 100° F), the requirement of a low cloud point on the grounds of safety appears to have little justification.

Although it is to be presumed that the book went to press before the XIVth (1950) edition of the U.S.P. was published it is a little surprising that the author does not mention the use of tocopherol as a stabilizer for liquid paraffin, since such use (permitted by U.S.P. XIV to the extent of 10 p.p.m.) is based on work done by his company.

In the chapter on methods of testing, the various tests to which white oil and petrolatum may be subjected are outlined. The U.S.P. (XIIIth edition) specifications for these materials are quoted in full, but other tests are only briefly mentioned with references to the appropriate A.S.T.M. or I.P. publications. It is unfortunate that the author should quote I.P. test designations such as 17/42 and 56/42, taken from older editions of " Standard Methods," in place of the respective numbers current at the date of publication of the book, *i.e.*, 17/45 and 56/46. Even some of the references to A.S.T.M. tests give numbers that are out of date, in some cases they were already obsolete as far back as 1947. Although the peroxide test is mentioned on several occasions, the account of it that is given is inadequate as a laboratory guide and, for this test, no reference is quoted.

The final chapter is devoted to shipping and handling. The remarks contained therein apply equally to any carefully refined petroleum product, and the directions for calculating quantities are a generally recognized procedure for liquid hydrocarbon products and not especially applicable to white oils. This chapter could well have been omitted.

Summing up; this publication is of considerable value in indicating the wide field wherein white oil and petrolatum may be applied and for the numerous recipes for products such as insecticides, pharmaceutical and cosmetic preparations, special lubricants, etc., that it gives. The section on test methods can be recommended as a useful summary for the non-technical personnel of the petroleum industry. As a wider treatment of the subject the book is, however, quite inadequate. V. B.

World Geography of Petroleum. Edited by W. E. Pratt and Dorothy Good. New York: American Geographical Society, 1950. London: Oxford University Press. Pp. xvii + 461. 48*s*.

The title of this most attractive and delightful volume very inadequately portrays its contents, for almost every aspect of the petroleum industry and its ramifications and repercussions are treated in a pleasing and refreshing manner. Twenty-one sections in four parts contain graphic contributions by recognized authorities on matters with which they are familiar and competent to expound views. Under the editorship of such an experienced oil man as Wallace E. Pratt, a vice-president of Standard Oil of New Jersey and an oil technologist of international repute, the selection of suitable material for a book of this character was assured. Although it does not pretend to be a scientific treatise, the contained articles epitomize nearly all known factors which determine a line of action whether prospecting for oil, developing oilfields, or distributing the products. Particularly valuable to those who have not travelled are the geographical descriptions of the various territories explored or exploited, enormously enhanced by the numerous excellent photographs which have been selected with skilful discrimination.

Information is given concerning every country in the world where oilfields are being operated or where prospects warrant reasonable optimism; and the subject matter of each noteworthy oil-producing country is supplemented by an interesting historical narrative that traces initial events to present-day developments. An unusual and welcome feature is the prominence given to sociological questions as influenced by oilfield operations in those countries where the exploitation of rich oilfields has resulted in raising struggling communities with a low standard of living to a state of affluence, causing thereby disquieting changes in the economy of a country as well as social upheavals if not revolutionary movements. Much valuable information is incorporated in each sector concerning the Laws, Regulations, Customs, and forms of taxation and royalties imposed by local or central authorities or negotiated with landowners or leaseholders. The incorporation in the chapters of useful statistical data, often in the form of tables or diagrams, is a great aid to readers.

Referring specifically to the context, Part I, after a geologist's foreword, reviews conditions that favour the formation of oil from organic substances enveloped and preserved in shore-line or deltaic silts and slimes, and refers to the prevailing conceptions of conversion by obscure chemical and biological reactions in which temperature, pressure, and catalysis may play a part. The probable importance of plankton rather than land-conveyed organic material as a source of the oil is stressed. This is followed by a concise account of the general principles that govern the separation, migration, and concentration of generated hydrocarbons into stratigraphic

traps. An excellent map facing p. 14 shows the great sedimentary basins of the world, which, in the view of geologists, warrant investigation for possible oil measures.

Modern ways of approaching an investigation of suspected oil terrain under the varied conditions that prevail are described, and the value of aerial observations and surveys is stressed, particularly where ground studies are obstructed by a topography or rank vegetation. The utility or importance of geophysical methods for detecting and delineating structural anomalies is also emphasized. Facts and figures are given to indicate the extent of the effort needed to meet the ever-increasing demands for petroleum products and the hazards connected with its search. Mention is made of the guiding principles that facilitate an estimation of oilfield reserves, and in tabulated form the accumulative production to January 1949 is given for all oil-producing countries together with their calculated reserves.

Eighteen pages in Part II are devoted by W. B. Heroy to a brief description of drilling and producing technique as now practised, and to an account of the measures taken for transporting crude oils and refined products after processing in modern refineries. Figures are given regarding the length, dimensions, and capacities of pipelines for oil and gas in a number of countries, in addition to the amount of surface storage needed to regularize distribution. World movements of oil products are diagrammatically illustrated.

In Part III sixteen separate articles by recognized authorities fill 288 pages and deal with the oilfield regions of the world, and for the sake of convenience the grouping is divided into a Western and Eastern hemisphere. The former group comprises a Caribbean area that includes Venezuela, Trinidad, Mexico, Columbia, and other Latin American countries, and North America. The Eastern hemisphere incorporates the Middle East as a whole, Saudi Arabia, Bahrein, the Union of Soviet Socialist Republics (Russia), Europe West of the U.S.S.R., Indonesia, British Borneo, Burma, and other areas in Africa and Oceania.

Three other contributions are devoted to a discussion of petroleum in the Polar areas, petroleum on the continental shelf, and major areas of discovered or prospective oil. Very naturally the immensity of the proved and potential oil resources of the Middle East, Venezuela, Texas and the Gulf Coast of the U.S.A., and of Canada are cautiously handled, for events in these spheres of activity have compelled oil companies to modify considerably their plans and ideas. The magnitude of the works already undertaken and in progress in those four regions is illustrated by a means of figures, maps, and photographs.

Part IV is entitled " Aspects of Utilization," and contains five informative papers under different authorship which discuss in a realistic manner the international and economic aspect of oil and future trends of production and consumption. Condensed in the space of seventy-five pages is an astounding accumulation of data and statistics connected with petroleum in times of peace and war. Questions that receive attention relate to reserves, environment of supplies, world utilization and consumption of oil products, future demands, conservation of resources, land and water transport, distribution, strategic supplies, supplementary sources of energy, and international struggle for control of supplies. The above list only imperfectly indicates the scope of subjects that are discussed with a freedom that is rarely found; and it is a pleasure to note a recognition of the fine achievements of British engineers in undertaking PLUTO pipelines across the channel for supplying the invading armies of the Allies with gasoline when re-occupying France.

The book is to be recommended to all interested in petroleum, for it is more than a convenient and happy presentation of published material and known facts, as the talented contributors indulge in a deal of common-sense speculation such as would appeal to all good wishers of the industry. Nothing but satisfaction if not pride could result from the narration of events which led to the search and discovery of valuable oilfields by enterprising and intrepid technologists financed mainly by Anglo-American and Dutch capitalists. Success was often obtained only after many years of strenuous efforts by a body of men who endured great discomforts, hardships, and dangers, exploring remote and unhealthy territories where sociological, climatical, and physiographical conditions combined to dispirit explorers and exasperate financiers. No wonder some impatience and resentment is occasionally expressed at the ingratitude of those administering some countries towards

those responsible for developing industries that have transformed life in their midst. Rabid nationalism often inspired by distorted or untrue statements has sown discord and suspicion where co-operation would have ensured greater benefits to all concerned and the world at large. Statements in various articles indicate to what extent the major oil companies had modified the original terms of concessions in order to meet the economic needs of a country or the wishes of their inhabitants.

The incorporation of a very comprehensive index and an extensive bibliography are attributes without which a book of this character loses much of its value.

A. B. T.

ADDITIONS TO THE LIBRARY

Physical Chemistry of Hydrocarbons, Vol. 1. Edited by A. Farkas, New York: Academic Press Inc, 1950. Pp. x + 453.

1950 Supplement of Book of ASTM Standards. Part 4. **Paint, Naval Stores, Wood Adhesives, Paper, Shipping Containers.** Pp. 340 + x. Part 6. **Electrical Insulation, Plastics, Rubber.** Pp. 284 + viii. Philadelphia, Pa.: American Society for Testing Materials, 1951.

ASTM Standards on Bituminous Materials for Highway Construction, Waterproofing, and Roofing. Philadelphia, Pa.: American Society for Testing Materials, 1948. P. 306, $3,00.

This is a compilation of A.S.T.M. specifications, test methods, recommended practices, and definitions relating to bituminous materials. Included are forty-nine methods of test, forty-one specifications (including three for creosote and one for testing sieves), two recommended practices, and three sets of definitions.

Standard Specifications for Benzole and Allied Products. 3rd Edn. London: The National Benzole Association, 1950. Pp. 233. 15*s*. net.

Since the 2nd edition (1938) of this work, new uses for benzole and allied products have necessitated changes in specifications to bring them in line with current practice. Thus, a new grade of pure benzole (Benzole-Synthesis Grade) and two additional grades of 10° xylole have been added, while many amendments are incorporated in this new edition.

In addition to specifications for thirty products, there are details of sixteen methods of test and instructions as to sampling, together with schedules of eleven pieces of apparatus.

Almost entirely, the book is printed on one side only of the paper.

British Standards (British Standards Institution, London).

B.S. 1709: 1951. Nomenclature of Drawing Instruments. Pp. 9. 2*s*. net., post free.

B.S. 1706: 1951. Electroplated Coatings of Cadmium and Zinc on Iron and Steel. Pp. 18. 2*s*. 6*d*. net, post free.

B.S. 781: 1950. Wrought Iron Chain Slings. Pp. 47. 6*s*. net., post free.

B.S. 1712: 1951. Cast Iron Economizers with Extended Surface Horizontal Tubes. Pp. 12. 2*s*. net., post free.

ASTM Manual on Measurement and Sampling of Petroleum and Petroleum Products. Philadelphia, Pa.: American Society for Testing Materials, 1950. 120 pp. $2.00 in paper cover; $2·65 in cloth cover.

This manual makes available recommended methods for measuring the volume (or weight in some cases) of petroleum and its products, and for obtaining representative samples thereof. It represents the results of ten years of investigation and research by Division II on Measurement and Sampling, ASTM Committee D-2 on Petroleum Products and Lubricants. The material has been reviewed by the Institute of Petroleum (England).

Included in the Manual are ASTM methods of gauging, temperature measurement, and sampling; a recommended practice for volume calculations and corrections; and tests for water and sediment by centrifuge, and gravity by hydrometer. There is also a proposed method of sampling liquefied petroleum gases.

The manual contains many photographs and figures that show the latest types of apparatus for gauging, temperature measurement, and sampling, and the methods are written in sufficient detail to permit the procedures to be followed without further instruction.

Physical Constants of Hydrocarbons Boiling Below 350° F. Robert Matteson. Philadelphia, Pa.: American Society for Testing Materials, 1950. 16 pp. $1.00.

This extensive compilation of tables includes most of the physical constants of 225 hydrocarbons (boiling below 350° F) which would be valuable to testing engineers and others concerned with the natural gasoline, synthetic rubber, industrial aromatics, and gaseous fuels industries. The work was carried out in conjunction with Technical Committee H on Light Hydrocarbons, of ASTM Committee D-2 on Petroleum Products and Lubricants.

Six classes of hydrocarbons are covered in the tables, including paraffins, mono-olefins, di-olefins, acetylenes and naphthenes, and aromatics. Only those compounds having good freezing-point data were included in the compounds tabulated, on the assumption that others had not been prepared in sufficient purity. Specifically, the tables include: name of compound, formula, molecular weight, boiling point, vapour pressure, freezing point, the three critical constants, liquid densities (in four systems of units), gas density (in three forms), specific heats (at constant pressure and constant volume), ratios of specific heats and liquid specific heats, gross and net calorific values, heats of vaporization, refractive index at two temperatures, air required for combustion, inflammability limits, aniline point, and octane number by two methods.

ASTM Manual on Quality Control of Materials. ASTM Committee E-11. Philadelphia, Pa.: American Society for Testing Materials, 1951. Pp. 127. $1·75.

This new Manual replaces the previous ASTM Manual on Presentation of Data, and is arranged in three parts.

Part 1 is a revision of the main section of the former ASTM Manual and discusses the application of statistical methods, other problems of condensing the information contained in a single set of n observations, and presenting essential information in a concise form.

Part 2 represents a revision of Supplement A of the old ASTM Manual and deals with the problem of presenting limits to indicate the uncertainty of the average of a unique sample of n observations. A form of presentation for use when needed in ASTM reports and publications is suggested; the restricted conditions under which this form is theoretically applied are given, and the meaning of such limits is explained, and a table is given to permit ready calculation of 99, 95, and 90 per cent "confidence limits" for various sample sizes. Working rules are presented regarding the number of places to be retained in computation and presentation of average, standard deviations, and confidence limits. In this revision the generally accepted term "confidence limit" is introduced, and constants for computing 95 per cent confidence limits are added.

Part 3 presents formulas, tables, and examples useful in applying the control-chart method of analysis and presentation of data as mentioned above.

Reviews of Petroleum Technology. Vol. 10 (covering 1948). London: Institute of Petroleum, 1951. Pp. viii + 350. 27*s.* 6*d.*

Statistics of Oil and Gas Development and Production Covering 1949. New York, N.Y., and Dallas, Texas: American Institute of Mining and Metallurgical Engineers, 1950. Pp. x + 456.

Statistics were assembled by the production review committee, petroleum branch, AIME. The U.S. is treated by states, and other parts of the world by countries, except for Far Eastern territories, which are included in one chapter.

Technical Publications 1948. Edited by A. E. Becker. Standard Oil Co. (New Jersey), 1950. Pp. ix + 512.

The third of a series of annual volumes containing a collection of papers written by scientific personnel of the Standard Oil Co and its affiliates. The twenty-four papers included were selected from more than 100 written by the company's technologists and published in scientific journals during 1948. Main subject headings are geology and production; manufacturing and fuel quality; rubber and plastics; analysis. Short biographies of authors are included.

APPLICATIONS FOR MEMBERSHIP OR TRANSFER

May 1951

The following have applied for admission or transfer to the Institute. In accordance with the By-laws, the proposals will not be considered until the lapse of at least one month after the publication of this *Journal*, during which time any Fellow, Member, Associate Fellow, or Associate Member may communicate by letter to the Secretary, for the confidential information of the Council, any particulars he may possess respecting the qualifications or suitability of the candidate.

The object of this information is to assist the Council in grading the candidate according to the class of membership.

The names of candidates' proposers and seconders are given in parentheses.

Applications for Membership

ADAMS, Earle Welby, assistant production superintendent, Kuwait Oil Co. Ltd. (*E. Boaden ; V. J. Chir.*)

BAAN VAN DEN BERG, Willem J., chief engineer, Shell Caribbean Petroleum Co. (*J. B. Kay ; C. C. Hook.*)

BAGCHI, Jogjiban, control officer, Indian Technical Development Establishment. (*M. P. McCarthy ; S. D. Saxena.*)

BROWN, Richard Percival, field superintendent, United British Oilfields of Trinidad Ltd. (*J. L. Andrews ; R. Mackilligin.*)

CONSIDINE, John Glynn, labour superintendent, Kuwait Oil Co. Ltd. (*E. Boaden ; R. M. S. Owen.*)

DIXON, Ronald Albert, assistant sales manager, British Alliance Oil Corporation Ltd. (*R. J. Wallis ; G. Sell.*)

DOUGARY, James McCulloch, assistant superintendent, Kuwait Oil Co. Ltd. (*E. Boaden ; R. M. S. Owen.*)

EMETT, John Robert Frank, assistant to the controller, Gulf Oil (G.B.) Ltd. (*A. Graham ; I. C. Montgomery.*)

FORGAN, Thomas M., assistant general manager, United British Oilfields of Trinidad Ltd. (*J. L. Andrews ; W. Mundden.*)

FRASER, Sydney Thom, assistant chemist, Kuwait Oil Co. Ltd. (*E. Boaden ; V. J. Chir.*)

HAMILTON, Robert Frederick, construction superintendent, Messrs. Costain-John Brown Ltd. (*W. E. Abraham ; W. M. Stirling.*)

HARRIS, Albert George, petroleum engineer, Kuwait Oil Co. Ltd. (*E. Boaden ; R. M. S. Owen.*)

HAWKINS, Hervey Carleton, technical advisor, Iraq Petroleum Co. Ltd. (*C. E. R. Sams ; G. Sell.*)

HOGG, Gordon Aubrey, assistant reservoir engineer, Kuwait Oil Co. Ltd. (*E. Boaden ; R. M. S. Owen.*)

HULME, Norman Eric, oil well driller, Kuwait Oil Co. Ltd. (*E. Boaden ; V. J. Chir.*)

JENKINS, Denis Frederick, operator, Anglo-Iranian Oil Co. Ltd. (*E. Spencer ; J. E. Brimley.*)

JORDAN, Leland Thomas, general manager, Kuwait Oil Co. Ltd. (*C. A. P. Southwell ; E. Boaden.*)

KELLEY, Henry Albert, control operator, Kuwait Oil Co. Ltd. (*E. Boaden ; V. J. Chir.*)

MCCULLOCH, Charles E., vice-president, Foster Wheeler Corporation. (*J. Primrose ; W. O. V. Hoyte.*)

MCGREGOR, Hugh Wallace, chemist, Scottish Oils Ltd. (*W. B. Peutherer ; A. G. Inglis.*)

MAJOR, Stephen Vine, technical consultant, Iraq Petroleum Co. Ltd. (*C. E. R. Sams ; G. Sell.*)

MESSENT, Ralph Lewis, production supervisor, Kuwait Oil Co. Ltd. (*E. Boaden ; R. M. S. Owen.*)

MIERAS, Alexander Adrian, assistant chemist, Kuwait Oil Co. Ltd. (*E. Boaden ; V. J. Chir.*)

NICHOLSON, Martin Richard, assistant to general manager, British Viscoleum Fuels Ltd. (*V. Biske ; E. Bowes.*)

PRANCE, Henry Waymouth, engineer, Iraq Petroleum Co. Ltd. (*C. E. R. Sams ; G. Sell.*)

REED, John Cameron, managing director, Eagle Oil & Shipping Co. Ltd. (*R. G. Mitchell; A. W. Sansom.*)
RICHARDS, George Selwyn, engineering inspector, "Shell" Refining & Marketing Co. Ltd. (*J. G. Hancock; R. B. Besley.*)
REILY, Stanley James, fire & safety officer, United British Oilfields of Trinidad Ltd. (*J. L. Andrews; R. Mackilligin.*)
ROWLAND, Raymond Peter, assistant chemist, Anglo-Iranian Oil Co. Ltd. (*L. A. Wilshere; G. Peace.*)
SHERLOCK, Oliver, manager, Messrs. Babcock & Wilcox Ltd. (*E. N. Hague; S. J. M. Auld.*)
SIMPSON, James, assistant chemist, Kuwait Oil Co. Ltd. (*E. Boaden; V. J. Chir.*)
SLATER, Alan Edward, assistant chemist, Esso Petroleum Co. Ltd. (*J. W. Clarke: A. Matsell.*)
SMITHER, Albert Lawrence, superintendent, Kuwait Oil Co. Ltd. (*E. Boaden; R. M. S. Owen.*)
WILSON, Kenneth Somerset, control operator, Kuwait Oil Co. Ltd. (*E. Boaden; V. J. Chir.*)
WILSON, Robert Douglas, chemist, Scottish Oils Ltd. (*E. M. Bailey; D. Stewart.*)

Transfers

DAVIES, William David, technical assistant, Fina Petroleum Products Ltd. (*A. Wilson; E. Attwood.*) (*Student to Associate Member or Fellow.*)
JACQUES, David Frank, research student, Birmingham University. (*F. H. Garner; F. Morton.*) (*Student to Associate Fellow.*)
TENNANT, Frank Edward, assistant petroleum engineer, Iraq Petroleum Co. Ltd. (*M. Griffiths; D. Glynn Jones.*) (*Student to Associate Fellow.*)

NEW MEMBERS

The following elections have been made by the Council in accordance with the By-laws.
Elections are subject to confirmation in accordance with the By-laws.

As Fellow

TUEMMLER, F. D.

As Member

CALDWELL, F. R.

As Associate Fellows

EGBEARE, T. H. E.
HODGE, H. P.
PALMQUIST, F. T. E.
RAINE, J. C.
SHAPLAND, J. D.
SHORTEN, G. A.
WILLIAMS, T. V

Transferred from Students to Associate Fellows

BROOKBANK, J. A.
BURGESS, B. H.
WATSON, K. J.

As Associate Member

SWAIN, A.

Transferred from Student to Associate Member

LESTER, L. J.

CORRECTION

TAYLOR, ALEXANDER HARTE. In the *Journal* for March 1951, Mr Taylor's employers were given as "The Anglo-Iranian Oil Co. Ltd." This should have read "The Burmah Oil Co. Ltd."

True to Specification . . .

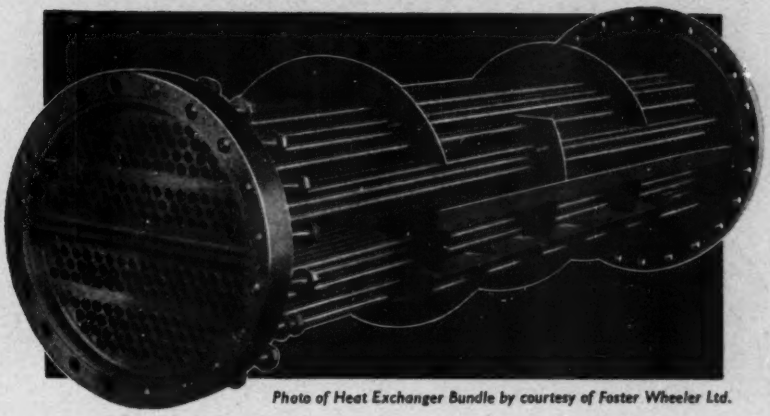

Photo of Heat Exchanger Bundle by courtesy of Foster Wheeler Ltd.

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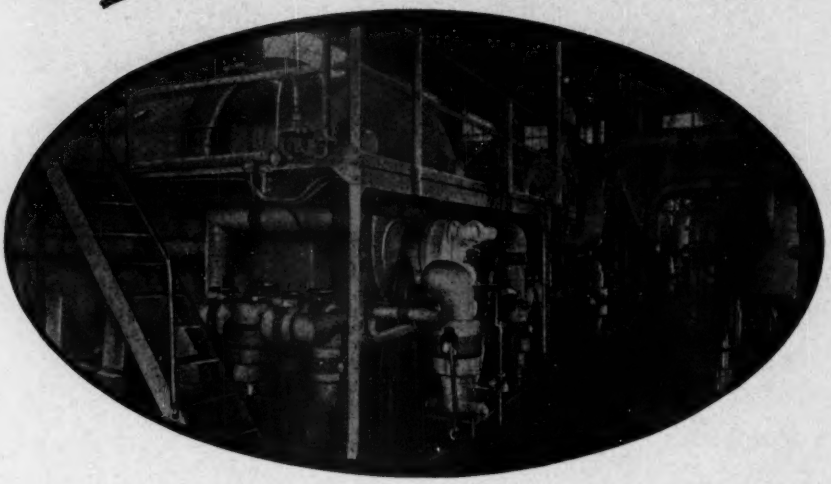

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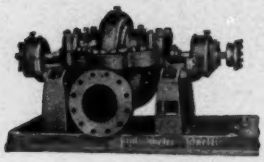

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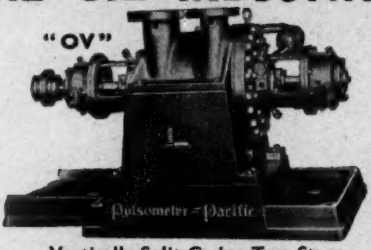

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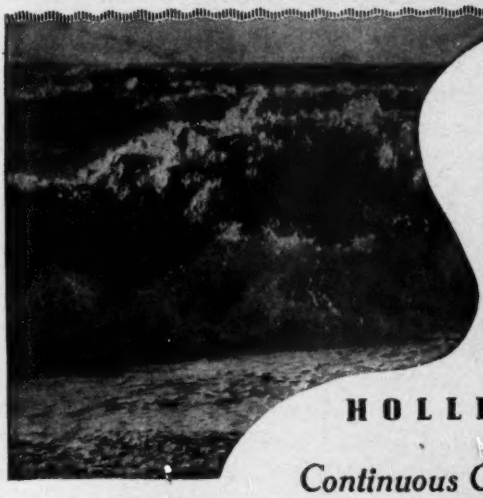

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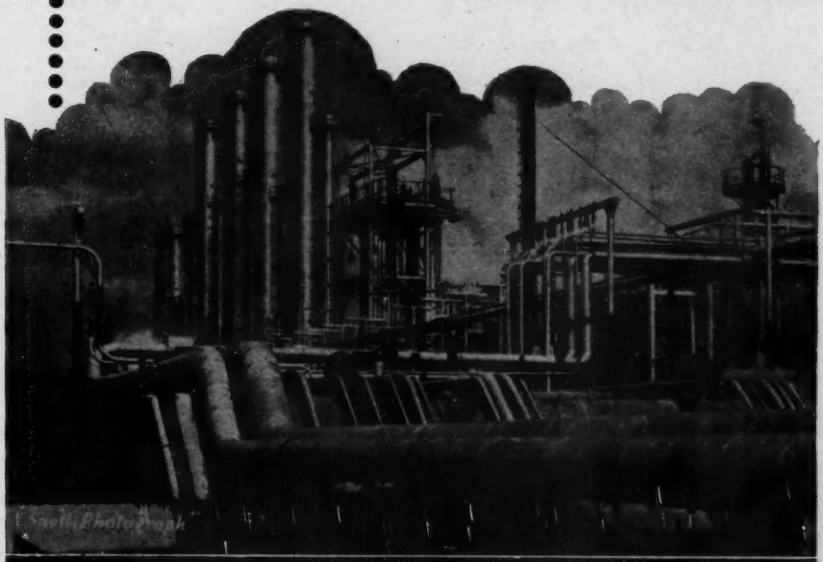

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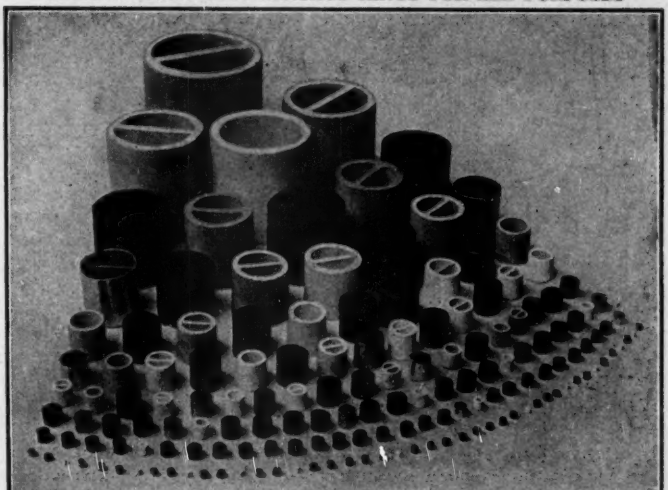

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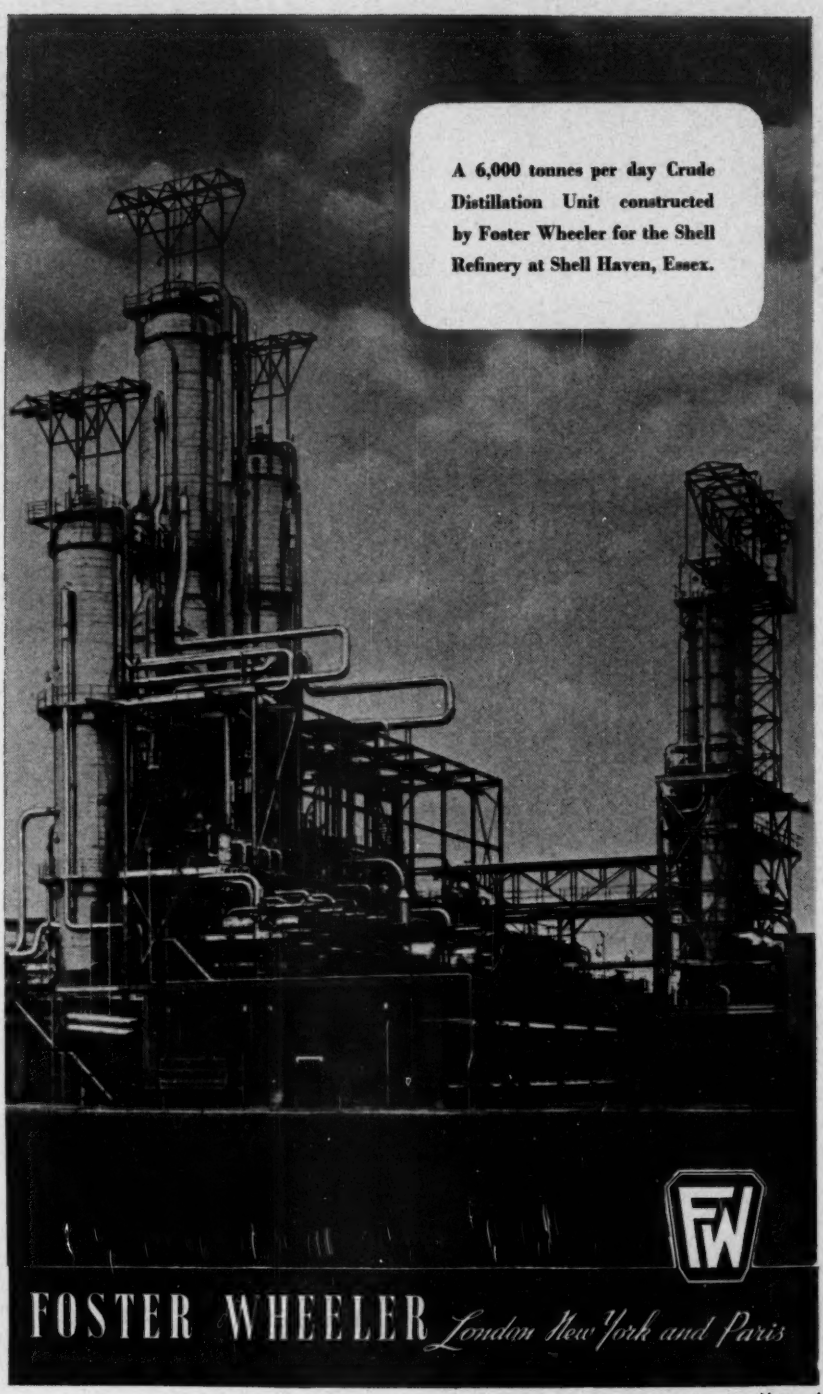
A 6,000 tonnes per day Crude Distillation Unit constructed by Foster Wheeler for the Shell Refinery at Shell Haven, Essex.
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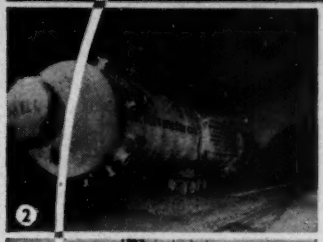

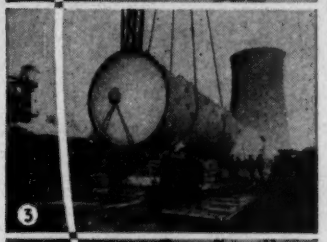

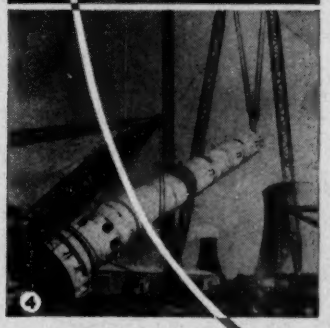

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FOR

STANLOW REFINERY

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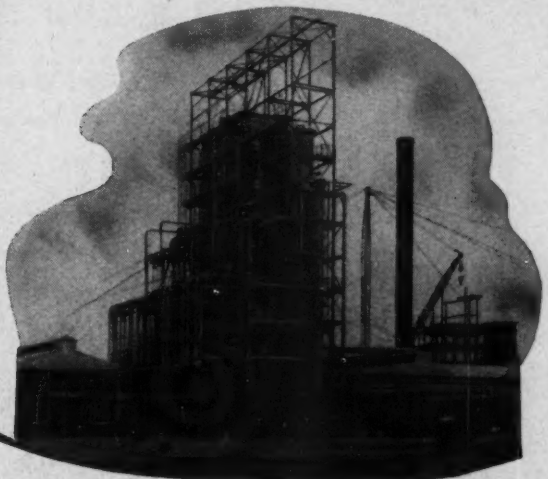

1 Fabrication of a pressure vessel in the Renfrew Works of Babcock & Wilcox, Ltd. Fusion welding of a longitudinal seam.

2 One Section (81 feet long, weighing 100 tons) part of a fractionating column 148 feet high and weighing 156 tons, entering the Mersey tunnel, en route to Stanlow refinery.

3 Sections of the fractionating column being positioned prior to welding together at site by Babcock engineers.

4 Raising the completed column into its final position.

The illustrations show fabrication, transport and erection of one of a number of Babcock pressure vessels, to the order of The Lummus Co. Ltd. for the Shell Refinery at Stanlow.

BABCOCK & WILCOX LTD

BABCOCK HOUSE, FARRINGDON STREET, LONDON, E.C.4

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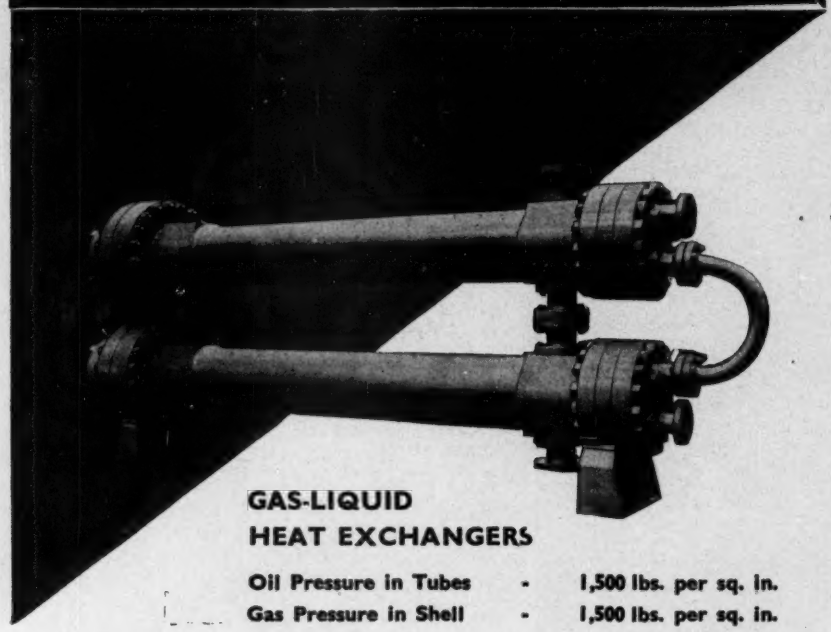

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HEAT EXCHANGERS

Oil Pressure in Tubes	-	**1,500 lbs. per sq. in.**
Gas Pressure in Shell	-	**1,500 lbs. per sq. in.**

The Shells of these Units consist of hollow forgings, the covers for the Shell and Floating End and the Liquid Channel being of Cast Steel.

The two Units shown form part of a battery of eight similar Units supplied to the Anglo-Iranian Oil Co. Ltd., for service in the AGHA JARI Field.'

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Esso
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An Esso photograph by William Martin Ltd.

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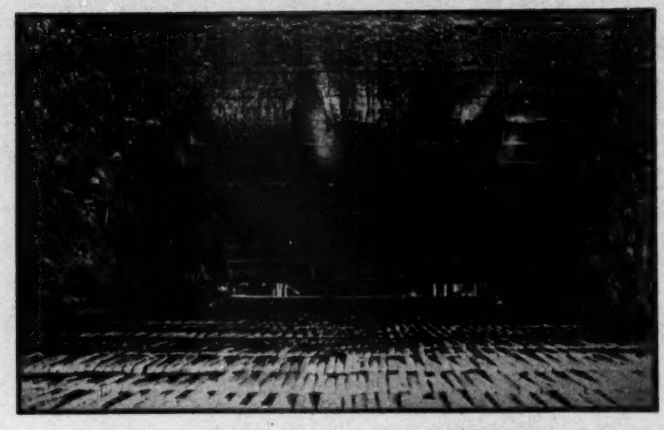

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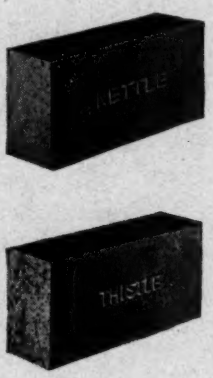
Full particulars of our Firebrick Brands, Refractory Cements, Castables and Concretes will be gladly sent on request.



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Process Pump Output -over 20,000 H.P.

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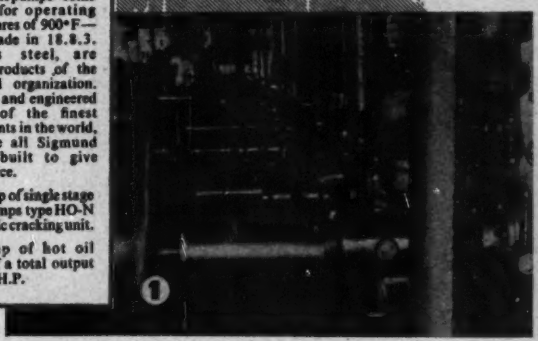

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English Steel Corporation have the facilities for making any known high grade steel, and the S.A.E. Steel used in the EDECO ROCK BIT is identical with that used by the American Rock Bit makers.

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The standard range now includes:

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for extremely hard and abrasive formations to overcome excessive Gauge wear.

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with special circulation nozzles for increasing the rate of penetration in soft formations.

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  Horton Double-Deck Floating Roofs, Horton Pontoon Floating Roofs, Horton Pan Floating Roofs, fitted with latest type Pantagraph Hanger for butt-welded tanks. (*Illustration shows tank 80 ft. dia. x 40 ft. high with Horton Double-Deck floating Roof.*)
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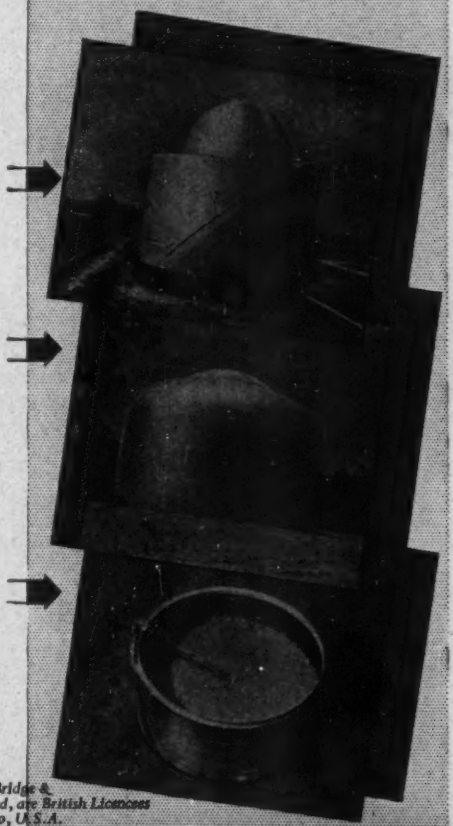

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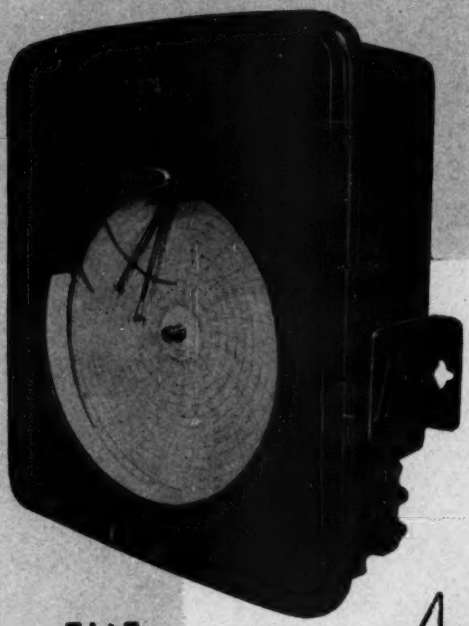

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SAID THE ANODE

TO THE CATHODE

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'These corrosion committees', said the Anode, spitting a stream of metal ions. 'Importance of surface preparation and red lead priming. Anodic suppression . . . ! Putting ideas like that about. How are we expected to live?'

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'I give up', said the Anode. 'Science just makes life more difficult . . . What's that noise?'

'Sounds like a brush to me', said the Cathode, 'and by the speed it's coming up it must be using that new paint. Brushes out fast and covers like the devil'.

'Look out!' said the Anode.

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***Rustodian** is made in self-colour peach, standard Light Stone and B.S.S. colours Light Brunswick Green, Dark Battleship Grey, and Imperial Brown.*

*An iron surface is never perfectly uniform and in the presence of moisture a number of electric cells form on its surface. Iron dissolves from the anodes causing progressive corrosion and pitting. At the same time, in certain circumstances, (such as in the presence of sodium salts from sea water), chemical compounds forming at the cathodes tend to destroy the paint film. Rustodian suppresses electrolytic action at both anodic and cathodic areas, and therefore retards the destructive effects arising from these causes.

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